JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXVI. AUGUST, 1888. No. 2.

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

FUEL OIL.

BY DR. CHARLES B. DUDLEY, Chemist, Penna. R. R. Co.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 6, 1888.*]

Dr. DUDLEY was introduced by the Secretary of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

Undoubtedly almost every one who has thought on the subject at all, has wondered why it is that petroleum has not come into more general use as fuel, and the more we think of the subject abstractly, the more wonderful it seems. Here is a substance which contains no ashes whatever, every portion of which can be burned up to produce heat, and in which from its composition every pound contains more heat-producing power than any other material, which exists in large quantities and over wide areas, with

(Dimensions in Millimetres.)

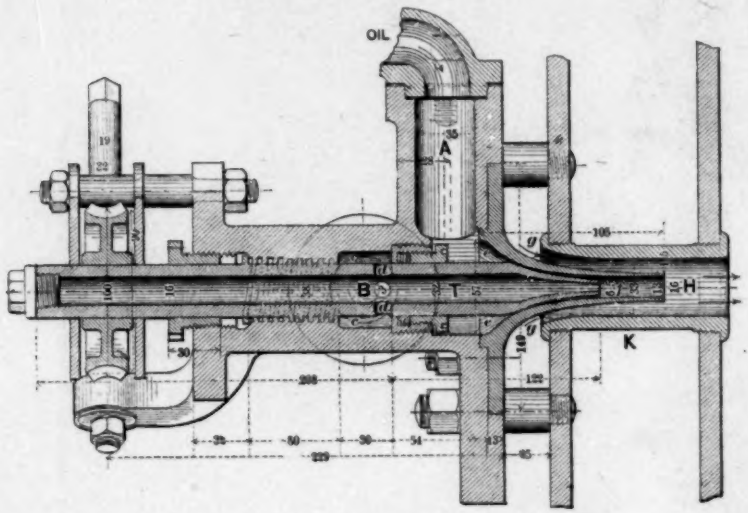

FIG. 1. The Urquhart Oil-Fuel Injector.

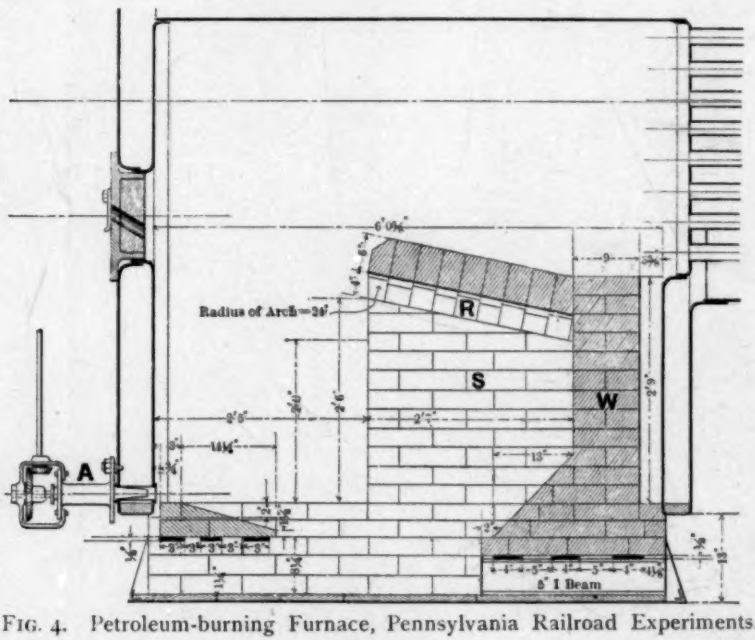

FIG. 4. Petroleum-burning Furnace, Pennsylvania Railroad Experiments.

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which we are conversant, and with these advantages in its favor, there must certainly be some good reason why oil has not been used more largely as a means of heat generation. If we succeed in what we attempt this evening, we will make the matter clear to you.

But before we take hold of this part of the problem let us examine together some other phases, for besides the real and most important reason, which we will discuss later, why petroleum has not been used for fuel generally up to the present time, there are other reasons which, up to within the last few years, have been very potent in preventing the use of petroleum for fuel. The first of these difficulties is that which we are met with at the outset, namely, how shall we burn petroleum? Coal, wood, lignite, etc., are solids, and to burn them it is only necessary to ignite them on a grate and supply the necessary air to keep up combustion. Oil, on the other hand, is a liquid and will not remain on a grate, so that the first difficulty really to overcome is to devise some method of burning the oil.

Experiments have been made by different inventors, more or less during the last ten or fifteen years, having for their object to devise a successful method of burning oil. Without attempting to give a connected or accurate history of these earlier experiments, it is perhaps sufficient to say that most of the experiments made, until within the last two or three years, attempted to convert the oil into gas or vapor before trying to burn it. In other words, a preliminary treatment of the oil or preparation of the oil was relied on as an essential step in the process. The general result of all these experiments has been that the preliminary treatment method did not prove successful. The generators used to convert the oil into gas or vapor would clog up and the preliminary treatment was expensive. A good many thousand dollars have been expended on these experiments, simply to learn that in order to burn petroleum successfully some method must be devised which takes the oil as it comes. Now, we know that previous preparation is entirely unnecessary, and that petroleum can be burned with perfect success and with almost complete consumption of the oil without any preliminary preparation or treatment.

It is perhaps difficult to say who first struck the essential feature of successful petroleum burning, but it is fairly safe to say that

Mr. Thomas Urquhart, of Borisoglebsk, Russia, Locomotive Superintendent of the Grazi-Tsaritzin Railway, made the first successful attempt on a large scale to use petroleum as fuel. Mr. Urquhart is a Scotchman by birth, and has been some nineteen years now in Russia, and when I visited him in October, 1886, he had some 143 locomotives in daily use burning nothing but petroleum, as well as a large number of stationary boilers, pumping engines, machine shop engines, etc. Indeed, the whole Grazi-Tsaritzin Railway uses almost nothing but petroleum for heat generation. The essential features of Mr. Urquhart's system of petroleum burning may be perhaps briefly described as follows: (1) The burner which converts the oil into a spray or very finely-divided condition; (2) the location of the burner in such a position in regard to the fire that it never becomes hot, and consequently never clogs; (3) the location within the fire-box of a mass of fire-brick so arranged as to form a combustion chamber and to serve as radiating points for the heat, and also to serve to a certain extent as a storage for heat. The fire-brick arrangement still further has the additional advantage of breaking up any particles of oil which escape from the burner unpulverized, so to speak, and also of re-igniting the oil after it has been shut off for any time, as when stopping at stations.

Let us examine these three features a little in detail by means of the diagrams on the screen, here shown in *Figs. 1, 2, 3, 4* and *5*.

(1) The burner. It will be observed that the burner is essentially two tubes. The inside one of these tubes carries steam taken from the boiler. The outside one contains oil taken from the reservoir on the tank. The burner is located as seen in *Fig. 2*, well down in the back leg of the fire-box just above the ash-pan. A thimble *H*, shown in *Fig. 1*, through the back leg of the fire-box forms the communication between the burner and the inside of the fire-box. The burner is supported on the back fire-box sheet by bolts, and stands about an inch away from this sheet. As wil oe observed, the inside tube, which carries the steam, forms a fit against the inside of the outside tube, and prevents the oil from passing through what may be called the combining tube, until it is desired to have it do so. The worm-gear on the back end of the burner, which is operated from the cab, serves to withdraw the inside tube and allow the oil to pass.

The operation of the burner is as follows: The cock on the pipe connecting the boiler to the inside tube being opened to pretty nearly its full extent, steam enters the annular recess, *c c*, and from it through the holes, *d d*, passes through the inside tube *T* and rushes into the fire-box. Now, by operating the worm-gear by the hand-wheel, shown in *Fig. 5*, this inside tube is drawn back and the oil allowed to flow in. When it reaches the end of the inside tube, it is caught by the steam and practically atomized, or converted into a fine state of division, the mixed spray, so to speak, being projected into the fire-box, as shown in *Fig. 2*. A bit of ignited oily waste on the end of a rod being stuck down through what was originally the fire-door, and which has been closed up with brick-work, except a small hole, ignites the stream of atomized particles, and the heat generation begins. As will be observed, the burner is exceedingly simple in construction. It takes the oil just as it receives it, and projects it into the fire-box in condition to be rapidly and completely consumed.

(2) The location of the burner. It will be observed that the nose of the burner does not reach into the fire-box. It is about an inch, or so, back in the thimble from the fire-box side, and in this condition never gets hot enough to decompose the oil, consequently no carbon is ever deposited and the burner never clogs.

(3) The fire-brick arrangement. The fire-brick arrangement may, perhaps, best be described as a sort of bonnet, with the open end of the bonnet toward the rear end of the fire-box. The bottom is more or less open for the admission of air. The back of the bonnet serves, as has already been stated, to receive any drops of oil that may escape being atomized in the burner and breaks them up by the rebound in condition to be burned. The bonnet itself is a sort of combustion chamber. After a good deal of experimentation, two methods of admitting the air were decided upon, both of which give excellent results. These two methods are shown in *Figs. 2* and *3*. In *Fig. 2*, the air is taken in at both front and rear. In *Fig. 3*, the air is taken in at the rear and the sides. Very little difference is noticeable in these two methods. Some forms of locomotive construction lend themselves better to one and some to the other. The small ledge shown just inside the fire-box, near the end of the burner, prevents dropping down of the oil, and also serves as a help in maintaining combustion.

Fig. 5 shows the general arrangement on a standard passenger engine on the Grazi-Tsaritzin Railway.

With above description and cuts it is perhaps not difficult to see why this method of burning petroleum has proved to be a success. The difficulties encountered by the earlier experimenters in breaking up the oil into vapor or gas do not occur with this method. The oil is burned just as it is supplied to the locomotive, with no other preparation than converting it into a finely-divided state. The burner is so located that it cannot clog, and if perhaps a stick or bit of dirt gets in the passage between the inner and outer tubes, it is only necessary to draw the inner tube back a little further, and allow it to pass into the fire-box along with a douce of oil, which produces no results other than a momentary out-puff of black smoke from the smoke stack. As has already been described, likewise the brick-work, which in operation becomes actually white hot, serves a very important purpose in this scheme, and although it cannot be regarded as absolutely essential, since there are systems of burning petroleum in successful use which do without the brick-work, it is unquestioned that much more uniform and reliable results are obtained with the brick-work than without it. The brick-work, well put up of good fire-brick, will last from six to eight months, but poor brick will not stand the intense heat.

It will be noticed that steam pressure has been previously described as essential in starting the fire. Air pressure may, of course, be used in place of steam, both in working the locomotive continuously and in starting up, and a number of experiments have been made with air to determine which was the more economical. No special advantages in favor of air have thus far been shown. When a locomotive is cold, it is customary on the Grazi-Tsaritzin Railway either to connect with the burner, by appliances for the purpose, a shifting engine already in steam, or when the engine is in the round house, connection is made with appliances arranged for the purpose from a stationary boiler. It takes from fifteen to twenty-five minutes with a cold engine to get up thirty to forty pounds pressure in a locomotive boiler, and when this pressure is once obtained, the engine will take care of itself.

There are two other systems of burning petroleum, one of which at least is in quite general use in southeastern Russia, namely, the Lentz system. This system is used a good deal on the

Volga steamers. It depends for its success apparently on the same principles that have already been described, namely, it converts the oil into a finely-divided state by means of steam, and burns this mixture of spray and steam. We believe there is no brick-work required, the material being simply projected into the fire-box. In this country, the Edwards oil burner has been used with considerable success, and this likewise converts the oil into a spray, doing it in a little different way, however, than the method used by Mr. Urquhart. We have seen likewise simply two pieces of tube, one inside the other, and with the control of the steam and oil by means of globe valves, the mixed steam and oil being simply projected into an ordinary fire-box. This is used on stationary boilers.

In the winter and spring of 1886 and 1887, experiments with the Urquhart system of burning petroleum were tried on the Pennsylvania Railroad. The devices used were practically the same as those used by Mr. Urquhart, but some little modification was needed. Locomotives in America are worked much harder than they are in Russia, and it was found essential to enlarge the burner a little, also the space for taking in air was found to be insufficient to prevent smoking, and the appliances for controlling the feed, which are operated from the cab, do not give quite as rapid movement as was deemed essential with the harder working engines of the Pennsylvania Railroad. The arrangements made use of on the Pennsylvania Railroad are shown in *Fig. 4*, which, as will be observed, are the same in principle, but with the modifications already described. *W*, is a fire-brick wall at the front end of the fire-box, with sides *S*, and an arch *R* on top. The air was taken in at the front and rear, the middle partition shown in *Fig. 2* being completely dispensed with, so as to allow the amount of air necessary to consume the oil. In place of the worm gear, likewise, for controlling the feed, a bevel gear acting more rapidly was used.

A single burner of the kind already described has been found to be abundantly sufficient to furnish all the steam required by an ordinary locomotive. The firing on oil-burning locomotives is simply ideal. The fireman sits on his box, or, as in Russia, stands at the wheel, with his attention fixed on the steam gauge and the smoke stack. He catches a glimpse of black smoke at the smoke stack; a slight turn of the wheel diminishes the supply of oil and

the smoke disappears. The engineer shuts off steam on arriving at a station. Instantly the supply of oil is shut off and the steam gauge scarcely changes a point. There is the most perfect relation between the violence of the exhaust, which means the amount of air pulled through the fire-box, and the supply of oil furnished. So perfect is this adjustment that it is not at all rare to see an engine, in which everything is working with perfect satisfaction, begin to smoke from a slight change in the relations between the exhaust and the supply of oil. So slight a change as the movement of the reverse lever one notch, which means a little less steam going through the exhaust, which means a little less violent draught, which likewise means a little less air drawn into the fire-box, will cause smoke to appear at the smoke stack. Of course this is entirely under control, and it is the fireman's duty to see that the steam pressure is kept up without smoke. Mr. Urquhart instructs his engineers to run on what he calls the "gray smoke," so as to be sure he is not drawing an excess of cold air through his fire-box. The gray smoke may be best described as the small line left after the steam has disappeared to mark the passage of a train on a clear day. Only those who are accustomed to it can detect the little smoke in the presence of the steam as it leaves the smoke stack. The comfort to the passengers by the use of this magnificent combustible for generating steam, can hardly be described. Not a cinder or a trace of smoke ever disturbs them. Windows can be left wide open, so far as the locomotive is concerned.

It is, perhaps, entirely safe to say, in view of what is actually being done, both on the Grazi-Tsaritzin Railway, on the Volga steamers and on the Trans-Caucasian Railroad in Russia, and also the experiments that have been made in this country to a greater or less extent, and in view of the description given above, that oil burning, so far as it depends on a method of doing the burning, is a success, and that this part of the problem is solved. Let us now turn our attention to some other phases of the problem. The practical part of the problem is solved; the how-to-do-it is clear; the problem that remains is, can oil be burned as a means of generating heat with economy?

This problem may be approached in several ways. Let us look at it by comparing oil with coal. The following table shows the relative heat-producing power of coal and oil. In this table, the

following assumptions are made. A pound of anthracite coal is supposed to contain ninety per cent. carbon. A pound of bituminous coal contains eighty-five per cent. carbon and five per cent. hydrogen. A pound of oil contains eighty-six per cent. carbon and fourteen per cent. hydrogen, and the heat-producing power of the carbon and hydrogen in the theoretical part of the table are calculated by means of the well known heat units of these two substances.

RELATIVE HEAT-PRODUCING POWER OF COAL AND OIL.

	Pounds Oil =	*Pounds Coal.*
Theoretical anthracite,	1	1·61
" bituminous,	1	1·37
Urquhart's experiments,	1	1·756
Peninsular Car Company,	1	1·742
Elevated railroad, New York,	1	1·785

It will be observed that Mr. Urquhart's experiments, which we may say are the result of a year's experience with the same 140 locomotives using coal and using oil, show that a pound of oil will generate as much heat as one and three-fourths pounds of coal. The experiments at the Peninsular Car Company, at Detroit, Mich., were made with Canadian petroleum in October, 1885, and show, as is observed, a very close agreement with Mr. Urquhart's figure. The experiments made on the elevated railroad, in New York, were made during the summer of 1887. It is very interesting to note that experiments made in different countries, at different times and by different experimenters, should show so close a relation in the amount of heat-producing power of coal and oil, and it is perhaps safe to say in general, which is the figure that Mr. Urquhart uses mostly, that a pound of oil is as good for producing heat as one and three fourths pounds of coal.

The ratio of coal to oil having been obtained, we are in condition to begin to study the financial part of the problem, and it is clear that thus far the oil has the advantage, for every pound of it is as good as one and three-fourths pounds of coal. However, oil is usually bought by the gallon or barrel, while coal is dealt in by the pound or ton. It is plain, therefore, that in order to get a figure representing the cost of doing a certain amount of work, either by coal or by oil, we need to bring these measures together. Assuming, therefore, that a barrel of oil contains forty-two gallons,

that a gallon of oil weighs 7·3 pounds, and that 2,000 pounds is a ton of coal, we have the two following formulæ, which will enable us to compute either the price that we can afford to pay for oil per barrel, if we know the price of coal per ton, or the price of coal per ton to be equivalent to oil at a given price per barrel :

$$\frac{\text{2,000 multiplied by the price of oil per barrel}}{\text{Weight of oil per gal.} \times \text{by no. gals. in bbl.} \times \text{by ratio oil to coal}} = \text{Equivalent price of coal per ton.}$$

$$\frac{\text{Weight of oil per gal.} \times \text{by no. gals. per bbl.} \times \text{by ratio of oil to coal} \times \text{price of coal per ton}}{\text{2,000}} = \text{Equivalent price of oil per barrel.}$$

By the use of these formulæ, the following tables have been calculated. And here it should be stated, that in actual practice it is found that there are certain economies where oil is used in addition to the economies in fuel account, notably saving in the cost of handling fuel and ashes, and economies in repairs to locomotives, especially fire-box repairs. This gives us two tables, one in which fuel account alone is considered, and the other in which all the ascertained economies are considered. As will be described in detail later, there are certain chances for economy in burning oil that do not occur with coal. Of these there have been pretty well worked out, as just stated, economy in handling fuel and ashes, and economy in repairs to locomotives. The amount of these has been obtained in dollars and cents and is, perhaps, best expressed by saying that, taking all ascertained economies into account, a pound of petroleum is as good as two pounds of coal.

RELATIVE VALUE OF COAL AND OIL, FUEL ACCOUNT ALONE CONSIDERED.

Oil per Barrel at	=	*Coal per Ton at*
$0 20		$0 74
30		1 12
40		1 49
50		1 86
60		2 24
70		2 61
80		2 98
90		3 35
1 00		3 73
1 10		4 10
1 20		4 47
1 30		4 85

Oil per Barrel at	—	*Coal per Ton at*
1 40		5 22
1 50		5 59
1 60		5 97
1 70		6 34
1 80		6 71
1 90		7 08
2 00		7 45

RELATIVE VALUE OF COAL AND OIL, ALL ASCERTAINED ECONOMIES CONSIDERED.

Oil per Barrel at	—	*Coal per Ton at*
$0 20		$0 65
30		98
40		1 30
50		1 63
60		1 96
70		2 28
80		2 61
90		2 93
1 00		3 26
1 10		3 59
1 20		3 91
1 30		4 24
1 40		4 56
1 50		4 89
1 60		5 22
1 70		5 54
1 80		5 87
1 90		6 19
2 00		6 52

It should be remembered in making all calculations as to the relative cost of coal and oil for heat production, the two must be taken in the same situation. It would be obviously incorrect to take the price of oil as quoted in the daily papers, which means the oil in the pipe lines or in the storage tanks in the oil regions, and compare it with coal in Philadelphia, which has already been transported from the coal regions to this point. The two must be compared in the same situation, and if the ratio of one pound of oil equals two pounds of coal are considered, the prices must be compared with the fuel ready for use, either on the locomotive tender, or in the tank at the stationary boiler. The formulæ and the tables will enable everyone to make the comparison for themselves for their own locality. It will perhaps be somewhat

surprising to those who have not made some calculations on this subject, to note that oil at three cents per gallon is considerably over $4 per ton for coal, and also to know that at present prices even crude oil at Philadelphia is difficult to be had at three cents per gallon.

Allusion has already been made to certain advantages which oil has over coal as fuel. Among these advantages the following may be enumerated.

(1) Less waste of fuel. Upon this point it should be stated that it seems probable that, with ordinarily constructed locomotives, working pretty hard and using a violent exhaust, at least as high as fifteen per cent. and possibly even twenty-five per cent. escapes combustion. There are three ways in which the fuel can escape: First, smoke and unburned gases which go out the smoke stack; second, cinders which go out the smoke stack; and, third, fuel which escapes through the grate. With oil, however, it is believed that combustion is practically complete. As said above, in oil burning a slight gray smoke is allowed to escape in practice, and it is also possible that some of the gases may escape unburned, but the loss is believed to be very much less than with coal.

(2) Economy in handling fuel.

(3) Economy in handling ashes.

(4) Diminished repairs to locomotives.

These three advantages have already been mentioned, and their money value has been obtained by experiment.

(5) Economy in cleaning engines. The absence of smoke and cinders around the locomotive when using oil is the source of this economy.

(6) Less waste of steam at the safety-valve. It is obvious that all the steam which goes out the safety-valve simply means so much fuel gone to waste, and until recently we have never known of any positive information showing how much this loss was. During the experiments made with oil on the elevated railroad in New York, it was found that it took twenty-five per cent. more water to do the same work with coal than with oil, and the explanation of this was the waste of water in the form of steam at the safety-valve. This loss on the elevated railroad is, of course, much higher than in ordinary locomotive practice, owing to the fact that the steam pressure must be kept as high as possible, that

an anthracite fire is a difficult thing to control, and that frequent stops must be made. It is probable, however, that in ordinary locomotive practice the waste of steam at the safety-valve may be as high as five per cent. and possibly more. With oil as fuel, it is possible to work for days without raising the safety-valve. During nearly a week's daily riding on the locomotives in Russia on the Grazi-Tsaritzin Railway, I only saw the safety-valve lifted once, and with proper care on the part of the fireman, there is no need of any waste of steam at the safety-valve.

(7) Economy in cleaning ballast. The cinders which are thrown out of the smoke-stack in coal-burning locomotives are a loss, not only because they are not burned, but because they fall on the track and choke up the ballast, especially where stone ballast is used. This choking of the ballast interferes with the drainage, and the result is every year thousands of dollars have to be spent in cleaning the cinders out of the ballast. It is difficult to say how much of a saving would be effected if oil alone was used, with consequently no cinders, but it is safe to say that it would amount to a good many thousand dollars on stone-ballast roads in a year.

(8) Economy of space in carrying and stowing fuel. A pound of oil does not occupy as much space as a pound of coal, and consequently a sufficient amount of oil to furnish a certain amount of heat could be carried in a smaller space than coal. This is of great importance on steamers, and of course not of relatively so great importance in locomotive practice.

(9) No fires from sparks. Oil burning being practically free from smoke and cinders, there are no buildings or other property destroyed along the track. How serious a difficulty this is with coal-burning roads it would take an examination of the damage account to show, but it is safe to say that it is not small.

(10) No smoke and cinders. It is difficult to put into money the advantages arising from the absence of smoke and cinders, but we will venture the assertion that the railroad that first adopts oil will distance its competitors in its passenger traffic, owing to the absence of smoke and cinders.

(11) Possibility of utilizing more of the heat. It may be, perhaps, not generally known that the size of the flues in an ordinary locomotive are decided upon by the ability of being able to keep

them from becoming choked up with cinders. A small flue is readily choked with cinders in coal-burning locomotives. On the other hand, the smaller the flue the more heating surface it is possible to obtain in the boiler, and the greater relative advantage is obtained from the fuel actually burned. If locomotives were constructed for oil burning, it would probably be easy to use flues one inch in diameter, instead of one and three-fourths or two inches as at present, with consequent ability to utilize more of the heat generated than is now done.

One or two points further very briefly. What kind of oil should be used? There are three reasons why crude oil should not be used, especially on locomotives, namely, it is more dangerous, it has an exceedingly unpleasant odor, and it is not so economical. As is well known, crude oil contains more or less gaseous matter, and also vaporizes quite readily. With the necessary use of lanterns and open lights around locomotives, there would consequently be more or less danger of explosions. Furthermore, in case of a wreck if the oil tank was ruptured, it would be almost impossible to prevent a fire. The odor of the crude oil need not be specially mentioned, further than to say that it would certainly be extremely unpleasant to ride behind a locomotive fed with Lima crude oil. The reason why crude oil is not so economical as reduced oil is because oil is usually sold by volume, and a gallon of crude oil instead of weighing, as we have assumed, 7·3 pounds, weighs about from six and one-fourth to six and one-half pounds, and as the heat is directly in proportion to the weight of the combustible, it is plain that a barrel of crude oil will not give as much heat as a barrel of reduced oil. The oil which is now used on the Grazi-Tsaritzin Railway, and which is believed to be safe to use, is an oil not below 300° fire test. It is fair to add that crude oil can be used on stationary boilers where it is kept in tanks and brought to the boiler in pipes.

The formulæ given above, and the tables, or rather the figures, which result from the comparison of the value of coal and oil in dollars and cents, go far toward explaining why petroleum has not as yet been used to a very much greater extent as a means of heat production, namely, in this country, and at the present time it is really more expensive to obtain the same amount of heat from oil than it is from coal. In the experiments already alluded to on the

Pennsylvania Railroad, it was actually found, with oil at thirty cents per barrel, that it cost nearly fifty per cent. more to take the same train of cars 100 miles by means of oil than by means of coal. Another very potent reason why oil has not and cannot, as we look at it, be used generally for fuel, is found in the following: The total coal consumption of the Pennsylvania Railroad, including all its ramifications, is about 8,000 tons per day. If, now, this fuel consumption was changed from coal to oil, the Pennsylvania Railroad alone would use over 26,000 barrels of oil per day, and this 26,000 barrels is over one-third, and at present nearly one-half, of the daily oil production of the United States, so that lack of supply in this country, at least, will, for a long time to come, prevent the use of oil in anything more than a very limited way. In Russia no difficulty of this kind occurs, and for two reasons. First, because the oil supply is enormously greater than it is here. While I was in Russia it was credibly stated that a new well had been struck which actually flowed more per day than the total daily production of the United States. The second reason is that the nature of the Russian petroleum is entirely different from American. With the largest portion of American petroleum, seventy-five per cent. is capable of being made into refined oil, leaving twenty-five per cent. of residues. In Russia the figures are exactly reversed; twenty-five per cent. only is made into refined oil, and seventy-five per cent. is residues, and these residues are what is burned. They have a fire test of about 320° to 340°, and look and, in truth, are very much like our ordinary reduced petroleum, known in market as "well oil," and used for lubrication.

The difficulty in regard to burning oil successfully has been overcome. Two other powerful difficulties still remain—increased cost for the same amount of heat, and limited supply, and it is for the future to determine whether either of these difficulties can be overcome.

As to the possibilities of the future it is difficult to say a great deal, but there certainly is very little hope for fuel oil as long as efforts are made to diminish production. It is possible, however, we think, that with present production, a limited amount of, say, 10,000 or 15,000 barrels per day of oil might be used to advantage as fuel, but it would probably require changes in the method of distillation with the idea in mind of making a fuel oil, and possible

changes in the methods of utilizing the heat generated, as has already been described, to get economy even in this limited way. There is also the rather paradoxical statement that those points farthest away from the oil fields can probably use oil to advantage, when it could not be used to advantage in the oil field itself. This is due to the fact that the same heat-producing power weighs less with oil than with coal, and consequently the freight, which is an important element always in the cost of fuel, would be in favor of the oil. In our judgment the future of fuel oil in this country, and until some other very much greater sources of supply are discovered, is in the hands of the refiners. By shaping the distillation in such a way as to produce a fuel oil at low figures, it can be burned, otherwise not.

SANITARY SCIENCE IN THE HOME.

By Mrs. R. H. Richards, Instructor in the Massachusetts Institute of Technology, Boston.

[*A Lecture delivered before the* Franklin Institute, *Friday, January 16, 1888.*]

The Lecturer was introduced by Dr. Frazer, Professor of Chemistry in the Institute, and spoke as follows:

It has been said that "the sanitary engineer sprang into existence on the passing of the Public Health Act in England in 1848, from which date sanitary knowledge began to spread and develop itself until twenty years later it was recognized as a science and special branch of study."*

Since just twenty years more have passed, we may consider sanitary science as now emerging from childhood into maturity, and while it has the freshness and piquancy of youth with some of the vagaries of childhood, not yet sobered by the trials of life, still we may reasonably expect it to begin to bear fruit in deeds worthy of the child of the age of philanthropy, the age in which all are to be benefited by the knowledge of the wisest.

* Association of Municipal and Sanitary Surveyors. Address of President Gordon. Leicester, England, July 18, 1887.

America was not far behind England, for in 1850 Mr. Lemuel Shattuck presented to the Legislature of Massachusetts a report, from a sanitary commission, which was as intelligent and as sound in its conclusions as Edwin Chadwick's writings in England.*

In 1869, the first State Board of Health was organized, that of Massachusetts; to its early reports I shall have occasion to refer more than once. In 1876 there were twelve, and to-day there are thirty-three States which have a State Board of Health.

So far sanitary science has been an ambitious youth, dealing with large problems, such as the draining of vast marshes, the building of asylums and hospitals, the water supply and drainage of cities, all works on a large scale, and needing an expenditure of money which no other branch of science has demanded. But we must acknowledge that even the vast outlay has had its reward. For Sir Douglas Galton has recently shown, that the average number of lives saved in each of the five years from 1880 to 1885, by sanitary improvements, in England alone, was 102,240. "A record, noble almost beyond compare, to the credit of the engineer as the benefactor of his species."

And yet while we claim sanitary science as a new science, its motto to day is that expressive hygienic formula given more than 2,000 years ago by Hippocrates, "Pure air, pure water and a pure soil;" and all its efforts have been directed toward supplying the people with these necessities But of what use is it to lay pipes carrying water to a community which still drinks at the well in the stable yard? or what use to build model tenement houses on clean soil, when in a year or two the occupants will have soaked it through and through with refuse which it is too much trouble to carry away? "Some years ago a wealthy and philanthropic land owner in one of our principal cities, conceived the idea of erecting a number of healthy houses, which should be built on scientific principles. Ventilation was especially sought, and the best talent at command was engaged to provide the necessary appliances; but when the houses were finished the owner found himself unable to retain his tenants except upon the condition that he would seal all his ventilators."†

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* *Hygiene in America.* Bowditch, Boston, 1877.

† *House Drainage.* James C. Bayles, p. 15.

The public in general are becoming familiar with and tolerant of works of public benefaction. Legislatures vote money for the support of State Boards of Health without much grudging. Common Councilmen appropriate hundreds of thousands of dollars for a water supply, and sometimes for the consequent drainage; even small communities consider it advisable to tax themselves for the general health. One hundred and three towns, beside twenty-three cities, in Massachusetts alone, have a public water supply.

Most of these large works, which after completion remain under the charge of competent engineers, and are maintained year after year, have been very successful. Other works of public sanitation, the care of the sick and wounded in great hospitals, the control and suppression of contagious diseases, in short all sanitary measures which are under the immediate and entire care of skilled men, in positions not interfered with by politics or personal interest, are duly appreciated and sustained. But when the question concerns the houses the people live in, and the food they eat, the wheel of progress has neither rolled so smoothly nor so far.

To be sure in house construction great talk is made about the sanitary authorities consulted, although the builders go on in the old way. It rarely falls to the lot of the thorough sanitary engineer to have his plans carried out when it comes to dwellings. All such schemes as need the personal co-operation of the individual are very likely to miscarry.

Dr. Boardman in his paper, "Value of Health to the State," in the Sixth Report State Board of Health of Massachusetts, 1875, well expresses this. "Sanitary science comes into constant contact with personal convenience, avarice, mistaken economy, long-established customs and habits, and an erroneous judgment of the future by the favorable condition of the present and past."

To the owner, a house is a sort of outer garment, and it is as much of an insult to tell him that his house is not right as to tell him that his boots need blacking. To the dweller in flats or an apartment house, the house he lives in is no more a part of him than the car in which he rides to town, or the public hall in which he suffocates. He depends entirely on the owner, takes it all on faith, as he does his dinner at the restaurant.

The relative positions of public institutions and of homes has

entirely changed since the infancy of sanitary science. Then the condition of asylums, hospitals, and public institutions was in glaring contrast to that of the clean, airy and roomy houses of the well-to-do people of the middle class, and even to that of the dwellings of the poor peasant and tenant. To-day the hospital and public institution receives the best that sanitation can give. Whereas a century ago it was almost certain death to be taken to a public hospital with a broken leg or a dangerous disease, now I would rather take my chance in any large hospital than in nine-tenths of the well-to-do homes of our land, simply because the essential principles of health are not at all understood by the people at large, and alas! not by all our physicians, who as a rule have been educated to cure disease, not to prevent it. Too many of them have been taught to fight Nature's laws, not to stand by patiently as her adjutant.

This has been called the urban age, the age of cities, and it often seems as if most of the ills which sanitary science is called upon to cure arise from the close contact of human beings in the crowded life of the modern city. From statistics carefully collected by Dr. Farr, in England, the following estimates are made. A population of 16,600 souls scattered over 100 square miles of territory are liable to lose by death 282 of their number annually. The same number of people drawn closely together so that they occupy fourteen square miles may lose 415 annually. The same number crowded into the space of a quarter of a square mile are pretty sure to lose annually by death 647, or one-twenty-fifth of the whole number.

Another way of expressing the same idea is, that the nearer people live to each other the shorter their lives. From the same statistics it is seen that a distance of 147 yards between habitations gives to the occupants an expectation of living to the age of fifty-one years. When the distance is lessened to ninety-seven yards, forty years only may be counted upon. Double the number of habitations, so that the distance shall be forty-six yards, and the mean of life will be only thirty-five years. Crowd the houses still closer and leave only seven yards between them and the occupants cannot count on more than twenty years of life, or only half that which they may reasonably expect if the houses are 147 yards apart. Why, then, do people gravitate so surely, like the

moth to the candle, to the maelstrom which will certainly shorten their term of life?

It is this very crowding of many people into a small space which makes possible the necessities of to-day, the electric light, the supply of gas and steam for cooking and heating. The delights of music and art, are they not unattainable except in the midst of large populations whose numerical and financial support can alone sustain them? Scatter our population over the surrounding country and you would put back the civilization of the time at least fifty years. We rightly boast of the height to which we have reached, but we do not stop to count the cost, to note the number of those who have fallen by the way. Those who climb highest are the few survivors of the fittest.

If the question were put to us now and here, "Would you rather live to three-score and ten, but live half a mile from any neighbor, and twenty miles from any city, or would you rather take the chance of losing one-third of the time, and live in the midst of the dust and confusion which necessarily attends the passage of the rapidly-rolling wheels of modern progress?" Who of us would not say, "Let me live while I do live." In one of his recent stories, George W. Cable expresses this feeling in the words, "They had done that dreadful thing that everybody deprecates and everybody likes to do—left the country and came to live in the city." But, we hasten to ask, is there no remedy? Must the enjoyment of all that is rich and delightful be paid for with such a price? There is no doubt that a city of Hygeia* could be built in which the death rate, and especially the sick rate, could be lessened far below that in any country town at present known. This city would not have more than twenty-five persons lodged on an acre of ground. It would be clean and so carefully supervised that disease could not find a foothold. But, if such a city should rise in a night and be offered to us to-morrow, who would go to live in it? Who would bear all the restraint of such a clean place? Americans claim the right to be the victims of their own ignorance and carelessness. They will not brook bridges across tracks and gates on the cars. The true American wishes to take the risk he incurs in jumping on or off a moving train;

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* *Hygeia.* B. W. Richardson.

and he also claims the privilege of living as he pleases. The picture of the city of Hygeia will be fascinating only when a large number of people are educated in the belief that health is the greatest of all blessings. The valuable little health primer, "Our Homes," written by Dr. Hartshorne, of Philadelphia, has before its title page these lines of Goldsmith:

> "A time there was
> When every rood of ground maintained its man:
> For him, light labor spread her useful store—
> Just gave what life required, but gave no more.
> His best companions, innocence and health."

Most great undertakings, from the building of the Pyramids to the Panama Canal, have been carried out at an enormous expense of human life, and it seems as if the development of all modern inventions, and the possibility of modern luxuries were to be attained only by a like offering of one generation to the next, but it certainly behooves us to be sure that there be no unnecessary sacrifice.

To live safely in the city costs far more than to live safely in the country. Shall we save money or lives? At present we are economical of expenditures and lavish of lives, as the examination of the vital statistics show. It is expensive to keep well in the midst of danger. The state has here to step in and assert its claim on the value of every man, woman and child to it, and to demand that it shall not be defrauded.

It has been said "that civilization, when it lifts man out of the savage state, adds to health and life and to length of days. But when it gives to civilized man more privileges than he deserves or requires, then civilization itself lapses back into practical barbarism, and nature, maintaining her unswerving and wise course, pursues her way even with death on her wings."*

As is natural to youth, sanitary science boasts of what it has done, rather than delights in calling attention to what remains to be accomplished. It is evident that the principles of water supply, clean building ground and all public improvements are well grounded, so that we may suppose that they will continue to gain in popularity. All great enterprises undertaken by sanitary engi-

* *Health and Life.* Dr. Richardson.

neering in its broad sense are a part of state medicine with which we do not now concern ourselves, but pure air and good food come under the personal control of the housekeeper. We have nothing new or startling to proclaim. We aim only to bring home to the householder his responsibility. *It remains for sanitary science to educate the people one and all.* It has to apply the knowledge it has gathered to that unit of the community, the home, for upon the welfare of the homes depends the welfare of the Commonwealth. It is therefore evident that upon this potent factor in public life should be lavished whatever of knowledge and of science the century has to give. At the birth of sanitary science this fact was recognized. It cannot be better expressed than it was in 1868 by Dr. George Derby, one of the apostles of state or preventive medicine, the first Secretary of the first State Board of Health in this country.

"The prevention of disease may be considered, first as regards the individual, or family, or household; and second as regards the community at large. What power have we to ward off disease from our homes? There are certain dangers to which we are exposed which a prudent head of a family may constantly bear in mind

"One of these and by far the most important, is from insufficient ventilation. Every man, woman and child is entitled to their full ratio of fresh air, to that amount which will both dilute and quickly remove all which has been spoiled by respiration and combustion.

"Fresh air is the great natural disinfectant, antiseptic and purifier, and not to be compared for a moment with any of artificial contrivance. There is plenty of it in the world, yet, disguise the fact as we may, there is no getting over the unwelcome truth that to provide it in abundance in our climate is expensive, since during seven months in the year it must be artificially warmed.

"All reforms are practicable whenever public opinion recognizes their expediency, and gives the necessary authority for their execution.

"Public health has so wide a field that help is needed from all. From the chemist, the engineer, the naturalist and from the humblest citizen as well as the highest statesman."

How, then, shall the home be reached in the most effective manner? How shall the moral responsibility of each individual be

awakened so that he will see to his own household first and then be a help and not a hindrance in carrying out measures for public benefit? How shall the people be instructed in the best ways of *obtaining* and of *maintaining* the three prime necessities of good health, namely, pure air, pure water and a pure soil? It is evident that a healthy community can be made up only by an aggregation of healthy individuals, and that upon the health of the individual must rest the health of the Commonwealth, as upon his wealth depends its prosperity, and upon his vote its political status.

Only one nation ever had this personal hygienic instruction, and only one national code of laws entered into the details of personal daily life with its sanitary requirements. The nation was that of the Jews, and the laws were those given by Moses. The nation had its reward, as will any nation to-day, which will take up in earnest the work of personal and home or family hygiene.

In this land of personal liberty, minute laws relating to daily life are not tolerated, but the truths upon which sanitary science is founded must be deeply impressed upon the public mind before we can look for great and important results. This popular education can be accomplished only gradually and by the patient and intelligent teachings of unselfish specialists, through the medium of newspapers, books, pamphlets and tracts. In all the avenues by which the masses of the people are reached, and in the opinion of many by that great artery of influence, the common school.

"The state, upon the legitimate ground of public economy and self-preservation, takes care of the primary education of the people; it, therefore, determines what secular knowledge shall be taught in the common schools. It may, and properly should, add the simple and ascertained laws of health and public hygiene to reading, writing, grammar, geography, arithmetic and the history of the country. It is a disgrace to our higher institutions of learning that they are still neglecting sanitary science."*

Dr. Wight also quotes Lord Derby as follows: "No sanitary improvement worth the name will be effective, unless you can create an intelligent interest in the matter among the people at large. You cannot make a population cleanly or healthy against their will or without their intelligent co-operation. This is why,

* *Maxims of Public Health*, p. 156. Dr. Wight.

of the two, sanitary instruction is even more important than sanitary legislation." Dr. Wight also makes a statement which, I believe, to be under rather than over the truth: "The unsanitary conditions of school buildings slacken the speed of educational progress more than one-third."

Grant, as we must, that some kind of instruction shall be given, in what must it consist? First, in what Edwin Chadwick called the sanitary idea; that is to say, "the idea that man could, by getting at first principles, and by arriving at causes which affect health, mould life altogether into its natural cast, and beat what has been hitherto accepted as fate, by getting behind fate herself and suppressing the forces which led up to it at their prime source." *

A sense of personal responsibility for the lives we have and the health we might have must be cultivated. We were not meant to drag out a miserable existence. We have not yet awakened to the fact that at least two-thirds of the illnesses under which we suffer are preventable, and that we are more and more to blame each day for allowing ourselves to lie under the unnecessary infliction. We are still in the middle ages in many things and in none more than in regarding disease as a special visitation of Providence, as something entirely beyond our control. Indifference to bodily health is a legacy handed down from the mediæval cloister. The ancients seem to have known better.

"Theoretically, we respect the physical foundations, but practically we say: 'We will build first our structure of domestic duties and social pleasures, of intellectual achievement, of philanthropic and church work, and then, if we find the physical underpinning a little shaky, we will prop it up with a tonic or a vacation.' But the physical life is no more to be established on this confused and chaotic system than the intellectual or the moral life. Health can be secured only by effort as continuous, as carefully adapted and as systematic as the processes of physical life themselves.

"If, for instance, we could save all our breathing for the year and condense it into the brief period after the spring cleaning, spasmodic effort would do very well. But, until the human body

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* *The Health of Nations.* Dr. Richardson.

can content itself with an annual breathing spell, the daily, hourly, momently need of pure, fresh air should be respected." *

When the sanitarian attempts to press home individual responsibility, his hearers answer: "Is life worth living if we have to take such care of ourselves?" They cannot realize that if the habit was once formed, it would not be care, only second nature.

In blaming people for this indifference, we forget that a body of men obeys the same law as a body of matter, *i. e.*, a body in motion will continue in motion, and a body at rest will remain at rest, unless acted upon by some external force. It sometimes seems as if the inertia of the human race was intensified inertia. This is expressed by intense conservatism on the one hand, when it is called upon to exert itself, or when the impetus or the exertion must come from within, and on the other hand its extreme readiness to adopt any new idea or fashion provided the impulse comes from without, and especially if some great saving of trouble or of exertion is promised. For instance, when coal was first used it was in the cities where the price of land drives the householder to store coal, as well as in a measure to live, down cellar. When the country dweller ordered his coal he had it also put down cellar, whence with much toil it must be brought up again for use, and nearly every house, to this day, no matter how abundant the land about it, has all the coal put down cellar. Again, the furnace is usually in the main cellar, whence the dust rises through all the rooms of the house whenever the furnace is shaken and the ash-pit emptied, instead of being enclosed so that the ashes and dust have no communication with the air ways of the house.

Some unusually indolent individual once upon a time hit upon the plan of introducing water into every room in his house. Immediately other people followed suit, with never a thought where the waste water went to, nor with what the pipes were connected. In many cases the pipes went nowhere beyond the house walls, and if they did connect with the city sewer the chances were that these same pipes ventilated the sewers into the houses. It is highly probable that this one fashion alone has caused more death and misery than war, and yet people demand it and architects supply the fatal demand.

* *Home Sanitation*, p. 73. Annie F. Allen.

A certain amount of conservatism may be pardoned since the most enthusiastic sanitarian must admit that there have been many sanitary cranks who have been a source of much discomfort to their friends, and who have brought discredit on the whole cause. In many cases it has happened that what was intended as a benefit has proved far otherwise. In many houses the sewer has been a source of fatal disease instead of a preventive. Indeed, in some directions, so far has the zeal of sanitary science outrun its discretion, that it is in danger of losing the ground it has gained. It has provided the mass of people with appliances for which they have no use, and it is a peculiarity of sanitary appliances that they are made for use, not ornament, although many a so-called sanitary plumber fits up a house on the reverse principle. The architect who does sometimes know what is right, builds a house which is very nice while it is new, and all the joints tight, all the pipes clean and free—large enough and not too crooked for what he imagines they should carry; but he does not consider that a few months' use will make a great difference; that joints will open and traps become unsealed; that a miscellaneous collection of match ends, coils of hair, dish cloths, and coffee grounds, to say nothing of a score or two pounds of grease, will stop up his pipes, and that the ventilators will remain closed because it is too much trouble to open them.

The criminal carelessness and neglect which so frequently rouses us to indignation against builders, really comes from the apathy of the public. A man does not buy a cotton mill, or a machine shop, without seeing for himself that everything is in order, that all the machinery works, and that there is power enough to run it successfully; but that same man will, in nine cases out of ten, buy or build a house for his family to occupy without seeing a single inch of pipe, without considering whether there is any outlet for the products of combustion of the numerous gas jets, without looking at the children's rooms to see if they can have fresh air without a draught. All is taken on blind faith, and that man will mourn the heavy dispensation of Providence when his child dies of diphtheria and his wife of typhoid fever.

It has been said that the highest modern civilization is shown, not so much by costly monuments and works of art, as by the perfection of house conveniences. But alas! security does not always

come with refinement, and the true conveniences of the houseare those only which add to the health and comfort of its occupants.

We boast loudly of our modern houses, and proudly show their increasing luxury and artistic furnishings (we certainly have good reason for boasting), but how about the people who live in them? What is life bringing them? Are they merely lounging in the lap of luxury, becoming daily more averse to activity, more self-indulgent, caring mostly for themselves? What are the pictures most commonly given to us in the current literature of the day, of the home life of our people? The husband and father is engaged in eager struggle for wealth, that his family may take a high place in society, or he is engaged in many large schemes for public benefit, and has no time to go about his house and examine its condition. He hires many servants, who ought to know their business. He never thinks of looking at the furnace, even if he is the proprietor of a machine shop, and understands how to make every pound of coal do its utmost there.

The wife and mother has her social duties and her charities to look after. Her children's clothes must be just right, and they must have their music and their French at the hours appointed; if they are late to breakfast and eat a hurried dinner, no matter, "it is safe to let children alone, they will get enough to eat."

The parlor maid is duly instructed in her duties, and everything is quite right in the dining-room, but what an expression of amazement would come over many a housewife's face did you ask her what was the condition of her cellar, or if 300 cubic feet of air a minute passed through every room. The children hurry off to school, hurry home, snatch a bite and run off to music, or to some appointment with a school-fellow; all is in a froth and a tumult; no time is given to the homely duties of the house. I sometimes think there can be no home without loving hands busied in the preparation of the daily tasks. The home must have the individual flavor about it. The ready-made house and ready-made outfit, servants trained by someone else to conventional duties, all this is to blame for the lamented decay of home life. Individual and family responsibility must be more fully recognized in school and in society before we can have the perfectly healthful home.

The child poring over his book in the evening, with his head close to a student lamp, complains of a headache. "Those lessons,"

says the mother, not stopping to think that it is the close air and the heat from the lamp, no matter how many laws of chemistry she has studied. She might remember that hot air being lighter rises to the ceiling and strives to get out at the top of the room; only an open fire or mechanical ventilation will pull it down and take it out of the bottom of a room. There is no connection between knowledge and daily life in the minds of most people.

One thing most urgently needed is co-operation of all those concerned both in building and living in houses. The architect must first of all understand his limitations. He must remember that the ancient civilization, whence he has his ideas of architecture, was developed in a warm climate, where the charcoal brazier, or the fire of a few sticks against the wall, gave all the heat needed. Civilization has gone so far toward the North Pole, that the open windows of the Greeks and Romans can no longer serve as fresh-air passages all the year round. One authority has said, "it is a fact which, unfortunately, does not admit of intelligent contradiction, that in the architectural practice of the time, very little attention is paid to the laws of health." The same author gives the *reason* on another page: "The architect in general practice cannot insist upon a due observance of hygienic laws in house construction, and compete successfully with those in the profession who are less conscientious in such matters. If his clients neither know nor care whether a house is well or badly drained, why should he drive away business by demanding that we shall pay for good plumbing work?"

Here again the public follows blindly the example of past ages, and shows its inertia in blaming the new fashions for its troubles. One writer has said, "there is probably more gratuitous abuse of one kind and another lavished upon plumbers than upon all other mechanics, directly or indirectly connected with the building trades. When the plumber, whom we call in to mend the pipe in some inaccessible place, has to tear up our floor or break down our walls, we never think of blaming the architect or builder."

To be a healthy home, the modern house, in a modern city, needs to have all the physics and chemistry of air and fire and water, as well as the mechanical points of construction, fully understood and carried out, both by the builder and the occupants. All must be of one accord, and the owner must expect to pay for the

good work without grumbling. We must frankly acknowledge that it costs money to be healthy and yet to enjoy the conveniences of modern life.

I must now speak some plain words to the housekeepers of my audience. I hope they will forgive me. I know no man will dare say it in so many words, and, therefore, it is the more incumbent upon me to do so. I am sure if the much-abused architects and builders were to speak their minds, they would say that it was the women who hindered them from carrying out the plans which they know to be best. How can a builder survive the scorn which greets him when he proposes to leave all the drain pipes exposed? How can he put hoods over the gas burners when the artistic sense of the woman who is to occupy the room is offended? How can he convince the women of the family that they should wear thicker clothing in the house in the winter and not expect to have a whole house made so comfortable that they can wear thin slippers and silk dresses in weather approaching that of the Arctic regions? Does it avail for him to argue with them? Must he not cater to their tastes? And as they are the ones who live nine-tenths of the time in the house, the man of the family lets them have their own way. There is a wide field for the sanitarian in girls' schools; the chemistry and physics which are now taught in them should have practical application to daily living, and not be given as disconnected subjects with no bearing whatever upon the home life. Women have been very averse to hearing such unpleasant topics spoken of, and all subjects relating to health have been tabooed. There is a change noticeable, however, and women themselves are awakening to the opportunities opening out before them. Mrs. Plunkett, in her "Women, Plumbers and Doctors," led the attack. College graduates form sanitary science clubs. The Boston Society to Encourage Studies at Home offers a course in sanitary science. A woman, writing for women, has said: "In this age of scientific enlightenment and invention and wide-spread information, ignorance of the primary conditions of health and vigor is unpardonable. A knowledge of sanitary principles should be regarded as an essential part of every woman's education, and obedience to sanitary laws should be ranked, as it was in the Mosaic code, as a religious duty." *

* *Home Sanitation*, p. 73, Annie E. Allen.

As this is supposed to be an age of money worship, one of the outside forces to be brought to bear is that of benefit to the purse. The individual must be convinced, as most states have already been convinced, that health is true economy. It has been estimated that on a broad average each individual loses from fourteen to twenty days a year by sickness. In a family of six persons, this would be one-third of a year, with probably as much outlay for physician, nurses, medicine, delicacies, extra fuel and travel in search of health, as all the other expenses of the family. In the case of the workingman this often means debt and despair. If it does cost much to give every member of the family his inherent right, pure air to breathe, it is economy in the end.

There is one point upon which I cannot forbear to touch. It is a subject which requires the most delicate handling, as it is impossible to treat it without disturbing some one. No subject has had so many theories concerning it, all of which have failed when put in practice. On no topic are people so sensitive. Even the best sanitarians have touched it lightly. Physicians avoid it. No one knows just how to approach it.

If I wished to make you smile, I could not do so more surely than by announcing to you that I was now about to consider the question of hygienic food. Yet I must in all soberness, ask your indulgence while I discuss the bearing of food upon health, promising that I shall consider it only from the hygienic standpoint, and that if anything sounds impracticable from a social standpoint, that I leave to be reconciled by those who have to balance their accounts between *society* and *health*.

The sanitarian says that an exaggerated importance is attached to both eating and drinking, and in the next breath he says that not half enough attention is paid to the providing of proper food. These apparently contradictory statements can be reconciled only by tracing certain customs back to their sources, and noting the causes which have produced certain effects in our daily life.

Eating and drinking was the principal *enjoyment*, as well as *employment* of the mediæval age. It was a step forward, indeed, to be able to *enjoy*, since the earliest races were probably able only to obtain a bare subsistence.

Baronial castles resounded with the revels of feasting, and since the feasters were likely to be killed in the morrow's foray, it was,

perhaps, as well, since intellectual advancement was not possible in such war-like times.

The life of the cloister was a protest against brute feasting, and we owe much stored learning to the ascetics who went to the other extreme, and only ate under protest, because it was necessary to keep body and soul together.

We seem to have combined the evils of both the castle and the cloister. We disregard every law of dietetics; we pay no attention to the real needs of the power-producing machines which we call our bodies. We give no heed to the high and noble possibilities, which only a perfect physique can ensure. Our tables are loaded with mixed and incongruous materials, far less digestible than the baron's roast ox. At dinner parties we eat, night after night, what is set before us, and give never a thought to the years each dinner is taking from our lives. Witness the slaughter of our public men! Can we not have the æsthetic side without sacrificing the hygienic? That we have become so careless is partly through ignorance and partly through thoughtlessness. It has been very unfashionable to consider the physiological side of the food question, and if one takes it up on the economical side, he is considered a traitor to American principles.

The advance in physiological chemistry has in the past few years shown us that non-hygienic diet has to answer for at least one-half the illnesses of civilized man. What priceless hours do we needlessly waste because of a little thoughtless indulgence, or even simply because it is the fashion to eat certain things. This is a state of things unworthy an intelligent people.

"We have not the least idea of the mischief that indigestion does us from the beginning of our lives. We say a person only suffers from indigestion, but if you cannot digest your food what do you expect to do?"*

It is stated, on good authority, that insane asylums are filled with the victims of indigestion and not with the victims of brain work.

Ask any physician what is the greatest drawback which he meets with in having his instructions carried out in the homes of his patients, and he will tell you that it is in the preparation of food.

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* *Health.* W. H. Corfield.

When a typhoid fever patient has a relapse, probably, in nine cases out of ten, it is because some loving and devoted member of his family or some careless nurse, has neglected a very small precaution. It is a terrible thought, and yet we must face some terrible truths in order to remedy the trouble.

To my mind there is but one efficient remedy for this gross ignorance and misapprehension of the office of food, and that is to have the science of food (not the technique of cooking) taught in all our public schools. The advocates of temperance would accomplish far more for their cause if they would advocate this fundamental teaching rather than teaching a special topic upon which we are rather more ignorant than upon any other physiological question.

Make the simple, fundamental, well-known principles of diet a part of the natural science training in the school, add interest and point to the teaching by classes in cooking, not for the sale of the dishes prepared, although they should be well done, but for the sake of the illustrations they give of the principles taught. The brains of most of us are reached quickest through the fingers. The element of time taken enters into the permanence of the brain impression.

While we know enough to make a beginning in this line, there is great need for further investigation. We very much need another Count Rumford to awaken an interest in the scientific side of food for the people. Matthieu Williams, an eminent metallurgist in England, and Prof. Atwater, the chemist, and Edward Atkinson, the political economist in this country, are calling attention to these problems, but they must be supported by public opinion.

"This work of the purveyor and the cook—the selection and preparation of our food—requires more intelligence of its purposes and means of accomplishing them, more consideration, careful judgment and discipline than any process submitted to human supervision. Much disease and disability, much distress and great loss of working power, both in body and in mind, and even premature death, are brought upon us in consequence of the misadaptations by the provider and unfitting preparations of the cook. These, the provider and the cook, are our life makers. We are in their hands, to make us what they can or will—strong or weak, buoyant or depressed, active or sleepy, clear, bright, quick-

witted, or dull and torpid. No office has such control over human power and effectiveness as that of the housekeeper and the cook. An office that yields so much power can be filled only by persons of high intelligence, appropriate culture and thorough discipline. No office offers so wide and rich a field for the exercise of talent and scientific acquirement.

"The eater's ideal of good food generally corresponds with the caterer's. There is also a very common sort of heroism or physiological stoicism in regard to eating. People often say, with self-complacency, that they can always eat what is set before them. Our domestic animals are more favored than their owners in respect to nutrition.

"The price, in money, in the general market, or the financial value of any service, is a good indication of the world's estimate of its importance. The wages of a cook are much lower than those of the maker of our garments. The groom who feeds the horses is paid twice as much as the one who feeds the family. According to the natural law, the character of the supply rises and falls in accordance with the estimate that is put upon it and the reward which is paid for it, in this as in other occupations. The talent which can rise high avoids the food laboratory, where it is meagrely paid, and goes to the clothes laboratory, where it is paid generously." *

Though this was written fourteen years ago, is not the same thing true to-day, and is it not a reproach to the mass of educated women that it is so? I have said elsewhere, "The time has come when the same kind of care must be given to the food of the family as the stock-raiser gives to his animals. The modern stock farm has given us most of the scientific knowledge we possess on the question of foods, and this is so because it pays to know the composition of their food. Shall the human animal be considered of less consequence?" †

It would seem appropriate to celebrate the coming of age of our youngest science in some manner which shall prove of great advantage to all mankind.

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* *Fifth Annual Report of the State Board of Health of Massachusetts*, 1874. p. 376. Dr. Edward Jarvis.

† *Food Materials and their Adulteration.*

It is a pertinent question to ask, what is most required in the way of sanitary effort? We have fairly good sanitary laws; we have Boards of Health and inspectors; we have the sanitary engineer proper, who attends to the construction of water works and to the draining of marshes; we have the inventor of safety appliances—alas! we have a surfeit of him; we have builders who can construct houses very perfect while they are unused. What more do we need? We need missionaries to go about among the people and show them the dense darkness in which they are living. There is knowledge enough available but "little of either fame or profit can be expected to result from this preliminary work in the field of sanitary reform."*

Hence there is required the true missionary enthusiasm, the philanthropic spirit, and most of all a faith in the responsiveness of men and women when they are once shown "how to do it."

We need those who are capable of showing people how to make the best of the homes they have, and of awakening a desire for better conditions. For this work there is needed a new profession, a home sanitarian, a home adviser, one who knows how to examine a house, not while it is empty, but while it is throbbing with the family life, one who can go the daily rounds with the house mother, and suggest many little points which make or mar the healthfulness of the home.

This is an office which the busy physician can never perform and which, until the physician's training is different, he is not, as a rule, competent to perform. The sanitary engineer, as at present trained, does not fully meet the requirements. Why should there not be the trained doctor of the home, as well as doctors of medicine? There are training schools for nurses; why should there not be training schools for home sanitarians, or better yet, since, beside a general knowledge of the laws of health, there is needed for this work a practical knowledge of the laws of chemistry and physics, so far as they relate to combustion, and to the movements of air and water, and especially a knowledge of the chemistry of food and nutrition, why should there not be a course in sanitation in the technical schools and the colleges? I believe that the University of Edinburgh does confer the degree of bachelor of

* *House Drainage.* Bayles.

science in the department of Public Health, and why should there not be a department of Home Health in American universities?

In this plan the family physician must co-operate, and since preventive medicine is slowly but surely making its way, in the not very distant future the two offices will be united and every family will have its physician paid by the year to keep its members in good health in so far as they will take proper care of themselves. From the eagerness with which mothers seize on anything which they feel will help them in their homes, I am led to believe that if some of the college-bred women would take up the profession of home sanitation or of sanitary adviser to the community in which they live, the result would be of the greatest benefit to the country.

That this is not beyond a woman's powers has been abundantly proven, and while this new profession ought not to be limited to women, yet in many of the points indicated improvements can only come through the better education of the housekeeper, and this requires teachers who are familiar with the difficulties with which the housekeeper has to contend.

Let the scores of young women who are looking to medicine as a wide field of usefulness go a step farther and add to their medical course a thorough training in preventive medicine and home sanitation. When this is done we shall soon see a reform in daily living worthy to usher in the twentieth century.

STANDARD MEASURES.

By E. A. Gieseler, C.E.

[*A Lecture delivered before the* Franklin Institute, *February 17, 1888.*]

Mr. Gieseler was introduced by the Secretary, and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

To measure the length of a line means to determine how many times the unit of length is contained in it. If the measurement is made by actual comparison of the unit with the unknown quantity, then it is called a *direct* measurement; if it is made by computation or construction, then it is called an *indirect* measurement.

On account of the imperfection of our instruments, as well as our sensual organs, direct measurements cannot be made absolutely correct, but will in all cases only be more or less close approximations to truth, the closeness of approach depending on the quality of instruments employed and the degree of care and ability with which they were handled. For these reasons, the direct measurement of a straight line, which is easy and simple in theory, presents great practical difficulties when high degrees of exactitude are demanded. The primary requirement will always be the knowledge with the greatest possible exactness of the unit of length, a requirement the importance of which has been fully recognized only in modern times.

The original units of length were found in the arm, the palm, the thumb, the foot, the step, etc., and from these various dimensions of the human body many of the still existing units have been derived.

The actual employment of dimensions of the human body for the purpose of determining the unit of length is not, as one might be inclined to think, a matter of a very remote past, in proof of which I will quote a book on surveying, published in Germany, by Jakob Koebel, about 340 years ago. In this book, the author

gives the following instruction (accompanied by a wood cut, which is reproduced here), as to how the length of a foot is to be found:

"To find the length of a rood in the right and lawful way, and according to scientific usage, you shall do as follows: Stand at the door of a church on a Sunday and bid sixteen men to stop, tall ones and small ones, as they happen to pass out when the service is finished; then make them put their left feet one behind the other, and the length thus obtained shall be a right and lawful rood to measure and survey the land with, and the sixteenth part of it shall be a right and lawful foot."

With such and similar crude methods to determine the unit of length, there could be no general concord in regard to it. Its length would be found different each time it was determined and a bewildering variety was the necessary result, which in many countries extends into quite recent days. In Italy, for instance, there existed in the year 1832, 215 foot measures of different length, and in Germany, at the beginning of this century, there were certainly not any less, probably many more. Some of these, with their lengths expressed in Parisian lines (144 lines to the

Parisian foot), are given in the following table, from which it will be seen that the differences between their lengths in some cases are very considerable:

Table, rendering the length in Parisian lines, of some of the foot measures in use in Germany about 1790.

	Parisian Lines.
1. Thorn,	117·8
2. Cologne,	121·0
3. Weimar,	125·0
4. Saxony,	125·5
5. Brunswick,	126·0
6. Frankfort,	126·2
7. Stuttgart,	126·8
8. Hamburg,	127·0
9. Danzig,	127·2
10. Dresden,	127·5
11. Munich,	128·0
12. Strassburg,	128·2
13. Bremen,	128·3
14. Lippe Schaumburg,	128·6
15. Mecklenburg Schwerin,	129·0
16. Bavaria,	129·4
17. Ulm,	129·5
18. Oldenburg,	131·2
19. Augsburg,	131·3
20. Halle,	132·0
21. Nurnberg,	134·7
22. Leipzig,	135·2
23. Prussia,	139·1
24. Vienna,	140·0

That such a chaos in regard to length measures could have been endured seems almost incredible now, but it must not be forgotten that in former times, when countries were less densely populated, and communication was difficult and slow, the importance of uniformity in this respect was not so universally felt as it is to-day. These remarks in a measure also apply to the United States, where during the Colonial and a great part of the Administrative period many units of length existed, which were considerably at variance amongst each other. While from the very beginning of our history the old English foot was introduced into the Colonies, and while we have therefore escaped the greater deviations that would necessarily have been incident on the independent creation of units of length in different parts of our coun-

try, we have not escaped the smaller deviations incident on inexactitude in copying the unit of length.

Hence, in a great measure, the perplexing difficulties and contradictions that are frequently encountered, when old surveys have to be referred to. In the surveys, for instance, made at various times of the land now covered by the city of Brooklyn, four different foot lengths have been employed, which are designated by Brooklyn surveyors as follows:

(1) The United States Standard;
(2) The Bushwick Standard;
(3) The Standard of the Twenty-sixth Ward;
(4) The Williamsburg Standard;

the difference between the longest and the shortest of them being about two inches in 100 feet.

The city surveyor of Brooklyn, when laying out a lot, has therefore to measure with the standard employed in the survey of that particular vicinity, so as not to set himself at variance with the old maps and surveys. In one case, the non-observance of this rule has led to the following unique state of affairs: In a block which is twenty inches too long, according to correct measurement, the lots have been laid out by starting from the two corners and measuring towards the middle with correct measurement. The result was that a strip of land twenty inches wide, belonging to nobody, remained between two of the centre lots. Houses have since been built on these lots, and between them still remains the ownerless strip of land, for which the city of Brooklyn cannot collect taxes from anyone, and which is therefore, from time to time, put up for sale on account of unpaid taxes.

The first attempts to regulate the question of length measures were made in France. In the year 1668, an iron toise (six feet) was inserted into one of the stone steps of the "Chatelet" in Paris, and this so-called "Chatelet Toise" was accepted thenceforward as the standard measure of France.

About fifty years later, Newton became convinced, through his philosophical researches, that the form of the earth could not be a true sphere, but must be an oblate spheroid on account of the stronger centrifugal force at the Equator. If this was true, then a degree of meridian measured near the Equator could not be as long as one measured near the Poles, a deduction which was not cor-

roborated by the actual geodetical measurements in existence at that time. In order to decide the dispute that arose in the scientific world on this question, the French government resolved to have measured two meridional arcs, one as near to the North Pole as possible, and the other in the vicinity of the Equator.

Two expeditions were accordingly sent out, one, under Maupertuis, to Lapland, and one, under Bouguer and de la Condamine, to Peru, each of them being furnished with an exact copy of the iron toise let into the stone step of the Chatelet. The Lapland expedition was shipwrecked on its return voyage, and on this occasion its iron toise was damaged to such an extent as to make it unfit for further use. The Peru expedition, however, returned with its iron measure in good condition, and the length of this so-called "Peru toise," at a temperature of 61° F., was now made the legal standard of France. The motive for this action on the part of the French authorities consisted in the fact that the proportion of the "Peru toise" to certain geodetical dimensions was known, and thus the idea of the natural standard was already foreshadowed. It was clearly defined by the two leaders of the Peruvian expedition as a measure, based on some constant length to be found in nature, and related to the same in a simple proportion, which would easily and permanently impress itself on memory, so that if the measure itself, and even all written records referring to it were to be lost through some catastrophe, it might always be reconstructed by re-measurement of the natural constant on which it was based. Bouguer recommended to adopt for this purpose the length of the second pendulum on the forty-fifth latitude; Condamine its length on the Equator.

Neither of these recommendations was carried out, and in the course of time they dropped out of sight entirely, until about fifty years later, under the reign of Louis XVI, when they were revived, together with a third proposition, namely, that of adopting the forty millionth part of the circumference of the earth, as the standard unit of length. After mature consideration on the part of the most eminent French scientists, this latter proposition was finally adopted, the main objection against the two first ones being that their adoption would carry the foreign element of *time* into the definition of the unit of *length*. In contradiction of the very common error that the metric system was given to the world by the

French Revolution, it may be stated here, that the decision in regard to its creation and introduction was reached under the reign of Louis XVI, before the outbreak of the Revolution.

In order, now, to obtain the length of the natural standard decided upon, as accurately as possible, the French government ordered a measurement to be made of the meridian of Paris between Dunkerque and Barcelona. This work was executed by Mechain and Delambre between the years 1792 and 1798, and from the results of it the meridional circumference of the earth was deduced, and the forty millionth part of it was made the French unit of length under the name of "metre."

Measurements executed subsequently by Lambton, Mudge, Svanberg, Schmidt, Gauss, Bessel and others, and made by the aid of finer instruments than were at the disposal of the French scientists, have shown the earth's quadrant to be about 860 metres longer than found by them. In the strictest meaning of the word, the metre cannot, therefore, be looked upon as a natural standard.

The length found by Mechain and Delambre was deposited by them in the State archives at Paris in the shape of a platinum bar about one inch wide and one-quarter inch thick, the two ends of which were one metre apart at the temperature of melting ice.

The careful construction and safe-keeping of such actual standards is looked upon to-day as the real and only safeguard against the loss of the unit of length, while the idea of the natural standard is not any more entertained.

The modern standard measures are kept in places affording the greatest possible safety, and are never used for actual measurements, but only for comparing purposes, this even being done under strict regulations. The Imperial Standard No. 1, of Great Britain, for instance, is accessible only once in twenty years, while for the ordinary purposes of comparison a copy of it, No. 6, is kept at the British Standards office, which is accessible at all times. The comparing of other measures with the Standards is done by means of instruments devised for this purpose, and called comparators, which will be described further on. There are two kinds of standard measures in use, viz: end measures and line measures. In the first-named the length of the unit is defined by the distance at a certain temperature between their ends; in the last-named it is defined by

the distance at a certain temperature between two lines drawn on their surface at right angles to the direction of their length.

When comparisons are made, the measures are generally supported on rollers, and it is unavoidable that the weight of the bar causes a slight flexure between the points of support. The comparison is, therefore, not made as it should be, with the actual length of the bar, but it is made with the cord of the curve into which it has been bent. In the case of end measures the measurement is taken from the centre of one end to the centre of the other end; that is, the cord pertaining to the neutral axis of the bar is measured. In the case of line measures, the measurement is taken on the upper surface; that is, the cord pertaining to the upper fibres is measured. Now, it was supposed that the length of the neutral axis cord was the one most approaching the true length of the bar, and for this reason end measures were formerly considered preferable to line measures.

Aside from this, end measures possess an advantage in the greater facility with which comparisons can be made by means of them, an advantage which is, however, offset by the danger to which their ends are exposed of becoming damaged through the contact into which they are generaliy brought with peculiarly constructed levers during comparison. It is said that the ends of the platinum Standard metre of the Paris archives were damaged after a comparatively short time to such an extent as to impair the correctness of the measure. To prevent further damage, actual contact during comparison with this Standard has since been forbidden by law.

The only way to overcome this defect of end measures is by constructing their ends of a very hard material, that will not appreciably suffer under the contact with the levers of the comparator. As a noteworthy example of this kind, I will here mention the old Prussian Standard, made in 1837, by Bessel, and probably the finest end measure that ever was constructed. This Standard consists of a cast-steel bar of square cross-section, into each end of which is inserted a sapphire, ground in the shape of a frustrum of a cone, and set in gold in such a way that the smaller end of the stone protrudes a trifle beyond the end of the bar, and that the two sapphire ends are three feet apart, at a temperature of 16½° C. Injury to the ends of this Standard is prevented by their extreme

hardness, and a displacement of them through the rusting of the bar is prevented by the gold setting of the stones.

The difficulties incident on the construction of such a standard have led in our days to the very general adoption of line measures, to the discussion of which I now proceed, taking as examples some of the Standards that are kept in the Coast Survey Office at Washington.

The first Standard measure of the United State is a bronze scale six feet and ten inches long and subdivided on silver to tenths of inches, which has been prepared for the Coast Survey of the United States by Troughton, of London. When this scale arrived in America it was subjected to a very close examination by Mr. Hassler, then Superintendent of the Coast Survey, and as a result of such examination the yard comprised between the twenty-seventh and the sixty-third inch was designated as the one most conforming to the average of the whole scale. On the strength of this, such yard was adopted by the United States Treasury Department as a Standard at a temperature of 62° F.

In the year 1856, the British government presented to the United States two authentic copies of the British Standard of length, which are designated in Washington as:

Bronze Standard No. 11 and Malleable Iron Standard No. 57.

Both are bars of square cross-section and somewhat longer than a yard; in the vicinity of each end there is a circular hole sunk down to the centre of the bar, into the bottom of which a small gold disc is inserted, on which are engraved five fine lines, viz: two in the direction of the length of the bar and three at right angles to them. The length of one yard is defined by the distance from the centre transversal line in one hole to the centre transversal line in the other hole, the parts of those lines to be used which are situated between the two longitudinal lines. The standard temperature was given by Mr. Airy, the Royal Astronomer, for the bronze bar at 61°·79 F., and for the iron bar at 62°·58 F. The object of locating the graduation of these Standards in the neutral axis of the bars, was to eliminate the error resulting from flexure, which was discussed above.

In comparing the two authentic Standards with the Troughton scale, it was found that the latter was too long. The intention having been to adopt the English measure and the Troughton

scale having been procured only with a view of getting as exact a copy as possible of it, it was now decided to introduce the authentic Standards received from the British government in its stead. This subject will be discussed more fully further on.

When measures constructed of different metals are compared with each other, then careful measurements must be made of their temperature, so as to take into proper consideration their different expansion. But while these measurements may correctly give the temperature of the surrounding atmosphere, they may, under circumstances, not give the exact temperature of the bars themselves. In order to obtain this value, which is evidently the one required in a direct and more exact way, Standards have been constructed, which form metal thermometers, on Borda's principle, and as an illustration of these, I will now describe the Standard metre, which was presented to the United States by the French government about 1850.

This measure is a planed and polished steel bar, the two ends of which are one metre apart at the temperature of melting ice.

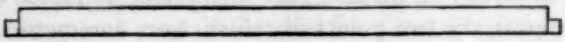


FIG. 1.

Upon each end of the bar there is screwed a small steel prism, reaching about half way across it, as shown in *Fig. 1*; the joints between the prisms and the ends serve as lines and the measure is therefore an end measure as well as a line measure. This steel bar rests upon a thicker and somewhat longer bronze bar, the two ends of which project beyond it, as shown in *Fig. 2*.

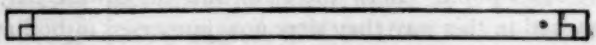


FIG. 2.

At one end the two bars are united by a pin, while at the other end they are free in their motions of expansion; to prevent any sideway deviations during these, there are four guide pieces attached to the underlying bronze bar, the top surfaces of which extend up flush with the surface of the steel bar.

One of the guide pieces at the free end of the bars bears a graduation and opposite to it the steel bar bears a vernier, by

means of which the relative movements of expansion of the two bars can be read off to hundredths of a millimetre.

This system of bars was placed in melting ice and kept there for two hours; the vernier at the free end then read 4·42$^{mm.}$

Then the system was placed in boiling water for two hours, when the vernier at the free end was found to read 3·80$^{mm.}$

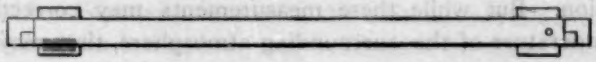


Fig. 3.

The difference of expansion between the two bars corresponding to a difference of temperature of 100° C. was, therefore, found to be 4·42 — 3·80 = 0·62$^{mm.}$, for a length of 954$^{mm.}$, that being the distance from the fixed point near one extremity to the zero of the vernier near the other extremity.

In order to determine the absolute expansion of each bar, an instrument was constructed by means of which a constant length could be inscribed on them. This instrument consisted of a steel beam compass, the two points of which were one metre apart at the temperature of melting ice, and which was constantly kept in a trough of melting ice, through the bottom of which its points protruded. The bars were now placed in melting ice for two hours and then the beam compass, always remaining in its trough, was placed on one of them in such a way that it rested lightly on one of its points, while with the other one a short arc of a circle was described; then this latter point was allowed to rest at the extremity of the arc just drawn and a similar one was described with the other point. Both the steel and the bronze bar, having been marked in this way they were now immersed in boiling water for two hours, and at the end of this time the process of marking on them the constant length of the beam compass was repeated in precisely the same way as before. The bars having lengthened under the influence of the higher temperature imparted to them, the distance between the second two marks would, of course, fall short of the distance between the first ones, and the difference between these two lengths rendered the absolute expansion for each bar for a change of temperature from freezing point to 100° C.

The following results were in this way arrived at:

Expansion of bronze bar, corresponding to 100° C., $1{\cdot}7030^{mm.}$

Expansion of steel bar, corresponding to 100° C., $1{\cdot}0502^{mm.}$

The difference between the two absolute expansions is $0{\cdot}6528^{mm.}$, which renders $0{\cdot}6228^{mm.}$ for a length of $954^{mm.}$, a result which agrees very well with the one found before by reading the vernier.

The coefficients of expansion corresponding to a change in temperature of 1° C. are:

For the bronze bar, $B = 0{\cdot}017030^{mm.}$

For the steel bar, $S = 0{\cdot}010502^{mm.}$

The difference between the two, $0{\cdot}006528^{mm.}$, reduced to a length of $954^{mm.}$, is 0·006228, which is the amount of change in the reading of the vernier for a change of temperature of 1°.

At the hand of these figures, it is now easy to determine the actual length of the steel metre for any given reading of the vernier. Let t be the temperature at which such reading is taken and let the following designations be introduced:

$M^0 = 1^m$ = length of steel metre at 0° C.

M^t = length of steel metre at t° C.

$l^0 = 4{\cdot}42$ = reading of vernier at 0° C.

l^t = reading of vernier at t° C.

Then we have:

$$l^t = l^0 - 0{\cdot}006228\, t$$

or

$$t = \frac{l^0 - l^t}{0{\cdot}006228}$$

Introducing into this equation the value for t, which we obtain from $M^t - M^0 = S\,t$, wherein $S = 0{\cdot}010502^{mm.}$, we have:

$$M^t - M^0 = \frac{l^0 - l^t}{0{\cdot}006228}\, S$$

or

$$M^t = 1^m + (4{\cdot}42 - l^t)\,\frac{0{\cdot}010502}{0{\cdot}006228}$$

in which equation the second term on the right side gives the amount in millimetres to be added to one metre in order to obtain the actual length of the steel bar at a temperature of t° C. The

amount of this temperature can be determined from the second equation given above.

Before leaving the subject of standard measures proper, their latest form should be mentioned, as devised by the International Commission on Weights and Measures, at Paris. This commission was created about 1870, and consists of delegates of nearly all civilized countries. Under its supervision standard measures of length are made of a composition of platinum and iridium and furnished to applicants.

FIG. 4.

The shape of the cross-section of these standards, which is shown in the diagram, has been devised with a view of combining lightness and strength, so as to reduce to a minimum the error incident on flexure. In the line measures, the graduation is located on the plane indicated by a heavy line, and in the end measures the point of contact is in the centre of the cross-section. As a matter of general interest, it may be added that the price of one of these standards is $2,500.

Having in the foregoing discussed various forms of standard measures, we now proceed to inquire into the appliances by means of which other measures are compared with them. Obviously there must be two classes of these comparators, one for end measures and one for line measures. The foundation principle of all of them, however, whether they belong to the first or to the second class, is the same, viz: that of magnifying the exceedingly small quantities with which they deal, in a known proportion, to such an extent that they can be discerned and measured.

One form of the first class is based on an application of levers with short and long arms, as shown in diagram 5. The fulcrum of the lever *A* is connected immovably with the support on which the bar rests, while that of the lever *B* can be shifted by means of a micrometer screw with a graduated head. The long arm of each lever carries a vernier at its summit, moving alongside of a graduated arc and is pressed in the direction of the arrow by means of a light spring. When a comparison is to be made, then

first the standard measure is placed between the short-curved arms in such a position that the vernier of lever *A* is moved through the contact to the zero mark of its arc; then the fulcrum of lever *B* is shifted by means of the micrometer screw until its vernier also reads zero, and now the reading of the head of the micrometer

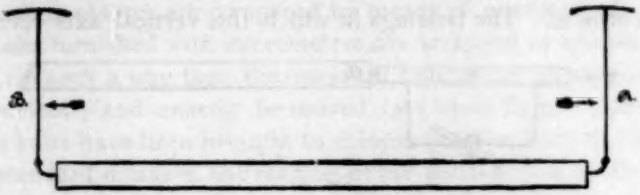


FIG. 5.

screw is taken. Precisely the same operation is then gone through with the measure that is to be compared, and the difference between the two readings of the micrometer screw then renders the difference in length between the two measures.

The support on which the measure rests is constructed in an instrument of this kind of two rules of different metals, one lying above the other and forming with it a Borda thermometer, similar to the standard metre described before. With the best instruments constructed on this principle, differences of the thousandth part of a millimetre can be measured.

Another form of comparator consists in a sensitive spirit level mounted on a strong brass plate, which swings around a horizontal axis. Through the brass plate passes a micrometer screw with a graduated head, the lower end of which screw is brought into contact with the upper end of the measure, this latter being placed in an upright position and its lower end resting on a fixed point at the bottom of the apparatus. After the standard has been placed into the described position, the screw is turned up or down, as the case may be, until the spirit level indicates the horizontal position of the plate, when the reading of the graduated head is taken. The measure to be compared is then treated the same way and the difference between the two micrometer readings renders the difference in length between the two measures.

A very ingenious construction of a reflecting comparator has been made by Mr. Saxton for the Coast Survey, and its main features may be described as follows:

While one end of the measure abuts against a fixed point, the other end, designated *A* in *Fig. 6*, is brought into contact with a small horizontal bar, *S*, sliding between guide pieces and being pressed lightly by a spring, in the direction of the arrow, against such end *A*. To the sliding bar are attached two arms, connected by a small chain which winds itself around a vertical axis, carrying a mirror *m m*. The bearings in which this vertical axis revolves

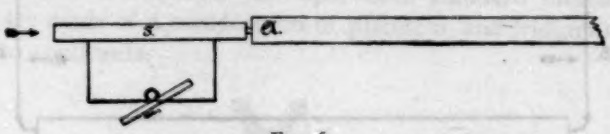


FIG. 6.

do not participate in the sliding motion of the bar, and the occurrence of such motion must, therefore, cause the mirror to turn with the axis to which it is attached. At a distance of about twenty feet from this apparatus there is a graduated arc of a circle, the centre of which is located in the vertical axis of the mirror. To the middle of this arc is attached a telescope, the line of collimation of

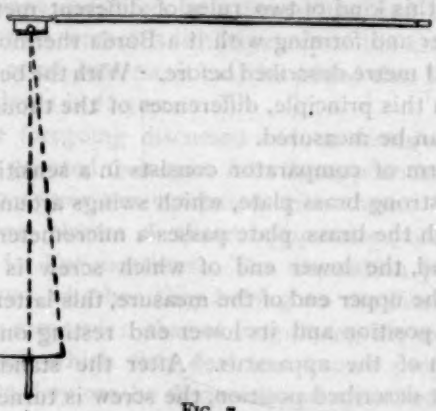


FIG. 7.

which is perpendicular on the direction of sliding bar and measure and passes through the axis of the mirror (see *Fig. 7*).

When the latter stands parallel to the sliding bar, then evidently the zero or middle point of the graduated arc will be reflected by it into the cross-hair of the telescope; any slight deviation from this position of the mirror will at once become apparent by another point of the graduated arc being reflected

into the cross-hair. From the difference of these reflected scale readings, the difference in length between two measures successively introduced into the apparatus is easily found, the limit of exactitude in the case of the Coast Survey instrument being the twenty-five thousandth part of an inch.

Line measures are compared by means of microscopes. Two of these, furnished with micrometers, are arranged as a beam compass, in such a way that the measure resting on its support can conveniently and exactly be moved into their focus. After the cross-hairs have been brought to coincidence first with the lines of the standard measure, the reading of the micrometers is taken and then the measure to be compared is introduced in the place of the standard and treated the same way. The difference between the two micrometer readings then renders the difference in length between the two measures. An apparatus of this kind in use at the Coast Survey building in Washington is arranged so that the bars are enclosed in a glass case during the comparison, the shifting and placing of them being done from the outside by ingeniously arranged levers, so as to avoid the influence of the heat emanating from the observer's body.

It is scarcely necessary to add that the successful handling of such instruments requires great experience and skill. To arrive at results as close as the small limits mentioned before is an exceedingly difficult and laborious process, during which numerous sources of error have to be carefully guarded against and which has to be repeated many times before the result is looked upon as well established. In this connection and in illustration of the great difficulties incident on the work of comparing length measures, some remarks may be quoted, made by Prof. Hilgard, late Superintendent of the Coast Survey, an acknowledged and widely-known authority. In the Coast Survey Report of 1876, he expresses himself as follows on the comparisons between the British Imperial and the American Standards:

"Extreme accuracy in this matter is beset with great difficulties, for in addition to that of ascertaining for each particular bar the rate of dilatation by temperature, there is an uncertainty in regard to permanence in the length of the bars themselves. Of the two Standard yards presented to the United States, one is of bronze (No. 11) and the other of Low Moor wrought iron (No. 57).

These are found to have changed their relative length by 0·00025 inch in twenty-five years; the bronze bar being now relatively shorter by that amount."

In further discussion of this remarkable fact, Prof. Hilgard says in the report of 1877:

"When we consider the constitution of any bronze metal, especially such as Bailey's metal, from which, on account of its great rigidity, the British bronze standards were made, and which consists of copper, sixteen parts; tin, two and one-half parts; zinc, one part; we will observe the fact that about five-sixths of the mass is composed of copper, a very pliable and ductile metal, while the admixtures have imparted to it great hardness and rigidity. This alloy was especially selected for the latter mechanical qualities, but the suitability of the molecular structure was not considered. In the light of our recent experience, we are permitted to assume, that the molecules of such a casting are in a state of great tension, which will yield under changes of temperature, and, if so, perhaps in less degree, to the simple effect of continuance. Hence while we admit that the shortening of No. 11 bronze relative to the Imperial Standard has taken place in consequence of the great variations of temperature to which it has been subjected, it is not improbable that No. 1 and No. 6 (British bronze standards) may both have shortened by the effect of time alone during the past twenty years, so as to make the excess of No. 57 (wrought iron) a reality rather than an accumulation of residual errors."

Having now discussed in a cursory way the history of standard long measures, as well as various methods of their construction and comparison, it remains finally to inquire into the practical application of all this in our own particular case; that is, to cast a glance at the ways pursued in adopting and introducing a uniform measure of length in the United States.

A stranger, unacquainted with the subject and seeking information on the same, would naturally turn to any of the manifold and well-known hand-books containing formulæ, tables and other information daily needed by the engineer. Suppose, now, he would first chance upon Haswell, "Mechanics' and Engineers' Pocket-Book," edition of 1887, then he would there find upon page 44 the following information:

"English Imperial Standard is referred to a natural standard, which is a pendulum 39·1393 inches in length, vibrating seconds in vacuo in London at level of sea, measured between two marks on a brass rod at temperature 63°.

"NOTE.—In consequence of destruction of Standard by fire in 1834 and difficulty of replacing it by measurement of a pendulum, the present Standard is held to be about 1 part in 17230 less than that of the United States, equal to 3·67 inches in a mile."

Suppose that, not being satisfied with one authority, he consults a second one, and this time happens to select Trautwine's "Engineers' Pocket-Book," edition of 1887, then he will there read to his astonishment:

"By law, the United States Standards of length are made the same as the British."

Not being able to harmonize these two statements, he concludes to fall back upon an English authority, and chooses D. K. Clark's "Manual of Rules, Tables, etc.," London, 1884, where on page 186 he finds:

"United States. Length. The measurements are the same as those of Great Britain."

Suppose that our inquisitive foreigner now concludes to inquire for the actual standard and, being in New York, is shown to City Hall. There, on the north wall of the western corridor, at a height of about five feet from the ground, he will find two lengths of ten feet each, marked on the wall, one of them designated as English and the other as Amsterdam measurement. Above them are the words: "Federal measurement," with a blank space opposite left for the purpose of marking the length. Although this has not been done yet, the setting apart for it of a space at the side of the English Standard is certainly strong evidence of the fact that the two measures were considered different.

The matter now stands two against two, and our inquisitive friend will probably give up his hunt for the American Standard, being afraid that further investigation might involve him in further doubts.

As a matter of fact, the English author's statement is the only correct one, while the writer is sorry to say that our two countrymen are in error. American measure is not any longer than English measure, as Haswell states, but it is precisely the same.

Yet it is not so by law as Trautwine states, because, unfortunately, Congress has never passed a law to this effect. The salient historical points in this question may be summed up about as follows:

The Standard yard of Great Britain was lawful in the Colonies before 1776. By the Constitution of the United States, Congress was empowered to fix the standards of weights and measures; it has, however, not made any use of this power as far as length measures are concerned, the only bills ever enacted on this subject being the following two: One approved of June 14, 1836, and empowering the Secretary of the Treasury to distribute complete sets of weights and measures to the different states, and one approved of July 28, 1866, legalizing the use of the metric system.

No new standard of length having been created by Congress to take the place of the old Colonial, that is, the British standard, this latter simply held over. The Coast Survey, in order to have a well accredited copy of it, procured the Troughton scale, and on the strength of Mr. Hassler's investigation, pronounced a certain part of it to be a standard at 62° F. When the comparison with the British government standards, received in 1856, had shown the Troughton scale to be too long at this temperature, then its standard temperature was accordingly corrected to 59°·4 F. On the strength of subsequent comparisons, made about 1874, by Mr. Hilgard, at the British Standards office, the standard temperature of the Troughton scale was once more changed to 59°·8 F., and after still further comparisons it is given in the Coast Survey Report of 1877, page 181, at 59°·62 F., at which temperature the yard contained between the twenty-seventh and the sixty-third inch of the Troughton scale is so far finally stated to be exactly equal in length to the British Imperial Standard.

It is quite evident from all this that the intention has always been to entirely and precisely conform our measure to the English measure, and that the acquisition of the Troughton scale, and the adoption of a part of it as a standard simply were steps towards this end, steps which were modified as soon as they were found not to have exactly led to the object in view. But the comparisons leading to these modifications were only commenced after the Troughton scale had existed for many years as the undisputed

American standard, so that its character, as such, had become so firmly rooted in the public mind, that the difference found between it and the British government standard, appears to have been looked upon by many as a difference between American and English measurement. This at least, in connection with the destruction of the British Standard by fire, in 1834, and the difficulties incident on its exact reproduction, seems to be a probable explanation of the origin of an erroneous statement of facts, which as we have seen, has even found its way into the best books of reference. There can be no doubt, that all uncertainties and misunderstandings in the premises would have been prevented, and a perfectly clear and definite knowledge would prevail everywhere, if this important matter had been dealt with, as in other countries, by an explicit act of the legislative body, and it is to be regretted that this has never been done.

Such action, if it had included proper provision enabling private parties to obtain correct measurement, would have been exceedingly beneficial, especially to that large class of professional men for whom an accurate and trustworthy length-measure is amongst the most important every-day needs. At present, the engineer, for instance, desiring to test the length of his steel tape, has to be exceedingly careful not to be deluded by so-called standards, that are worthless notwithstanding a certain show of authenticity.

In the writer's own recent experience, he found three public standards in New York and Brooklyn at variance amongst each other so much as to make it unsafe to trust to any of them. In the very metropolis of this continent there was, therefore, no reliable official way of obtaining correct measurement, and the writer was compelled to address himself to the Coast Survey at Washington for this purpose.

A NEW CALORIMETER.

By Cecil H. Peabody.

The form of calorimeter here described was devised to determine the quality of moist steam, and introduced into the mechanical engineering laboratory of the Massachusetts Institute of Technology. Several other forms have been in successful use there, but this one appears worthy of notice on account of the simplicity of its construction and the ease of operation. Its action depends on the fact that the total heat of saturated steam increases with the temperature or pressure, and that consequently saturated steam becomes superheated when it is allowed to expand without doing work. If the steam is moist, the excess of heat at the higher pressure, above that at the lower pressure, is expended first, in vaporizing the water present, and second, in superheating the steam.

In the figure *A* is a piece of steam pipe six inches in diameter and ten inches long, capped at both ends. Into the caps are screwed the several fittings required. A half-inch pipe *a* brings steam to be tested; the branch *c* has a drip cock at the end to allow the water condensed against the sides of the pipe to escape, the branch *b* leads to the calorimeter, and is provided with a globe valve which is opened a fraction of a turn to admit steam to the chamber *A*. An inch pipe *d*, diagonally opposite the mouth of the pipe *b*, allows the steam to escape at a lower pressure; it is also provided with a globe valve by which the pressure in the chamber can be regulated.

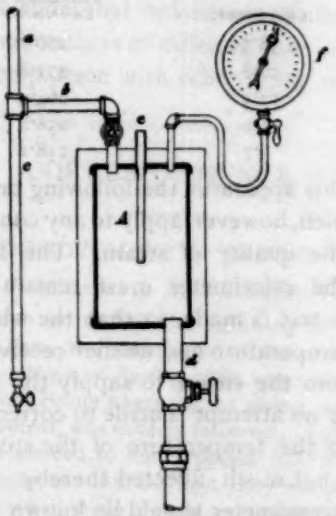
The thermometer cup, *e*, is made of a thin brass tube with the lower end closed, brazed into a thicker tube, which has a pipe thread cut on it, and which is screwed into the upper cap of the calorimeter with pipe tongs.

At *f* is a pressure gauge, which gives the pressure of the steam in the calorimeter. The pressure of the steam in the boiler or steam pipe from which the pipe *a* leads, should also be taken, pref-

erably by a gauge having a separate communication, but if the valve in the branch b is open only a slight amount, the gauge may be attached to the pipe a.

The chamber A is covered with asbestos board and hair felt, and may be enclosed in a case of sheet metal. The pipe a, the branch b and the valve in it are thoroughly wrapped with hair felt or other non-conducting substance. It is not necessary to wrap the pipes c and d.

To make a test, regulate the pressure in the chamber A by aid of the valve at d, so that the temperature shown by the thermometer at e shall be higher than that due to the pressure shown



by the gauge f. After the gauges and the thermometer have remained steady some minutes, note the pressures and the temperature, and also note the height of the barometer.

Let p be the absolute pressure in the steam pipe or boiler, and let q and r be the heat of the liquid and the latent heat of vaporization corresponding. Let p_1 be the absolute pressure in the chamber A, and let t_1, q_1 and r_1 be the temperature, heat of the liquid and latent heat of vaporization corresponding. Let t_e be the temperature by the thermometer at e. Finally, let the mixture of steam and water in the pipe a be composed of x part of steam and $1-x$ part of water. The specific heat of superheated steam

is given by Regnault as 0·4805. Assuming that no heat is lost by radiation or changed into work

$$x\,r + q = r_1 + q_1 + 0{\cdot}4805\,(t_s - t_1)$$

$$\therefore x = \frac{r_1 + q_1 - q + 0{\cdot}4805\,(t_s - t_1)}{r} \qquad (1)$$

and the per cent. of priming is

$$100\,(1 - x) \qquad (2)$$

The following table gives the results of several tests made in the Institute laboratory:

Gauge Pressures.		*Temperature Fahrenheit in Calorimeter.*	*Per Cent. of Priming.*
Boiler.	*Calorimeter.*		
71·2	38·5	286·7	1·1
60·3	26·8	271·8	1·2
63·0	17·5	264·9	1·3
60·6	7·0	258·8	1·1
69·0	3·7	258·1	1·2

In the use of this apparatus the following precautions are to be observed, all of which, however, apply to any continuous calorimeter for determining the quality of steam. The boiler pressure and the pressure in the calorimeter must remain constant for some minutes before the test is made, so that the whole apparatus shall be at a constant temperature and neither receive nor give up heat save that taken from the steam to supply the external radiation. In this calorimeter no attempt is made to correct for radiation, but it is probable that the temperature of the steam in the centre of the calorimeter is not much affected thereby. The errors of the gauges and the thermometer should be known from recent determinations. It is to be noted that if the steam is superheated five degrees or more an error of two degrees in the temperature will have a very slight effect on the result. The gauges used should be divided to single pounds and should be compared with a reliable mercury column. The gauges on the market though sufficient for ordinary uses, are seldom accurate enough for this work, and they are liable to change during use. Unfortunately, a comparison of gauges with each other is of little avail since the errors vary irregularly.

The application of the calorimeter is limited to cases which have a small or moderate per cent. of priming. If the priming is

excessive the steam in the calorimeter will fail to be superheated. For any range of pressures the limit may be determined by a calculation similar to that of equation (1), making $(t_s - t_1) = o$. Thus, with 100 pounds absolute pressure in the boiler and atmospheric pressure in the calorimeter, the steam will fail to be superheated if the priming exceeds four per cent. With lower pressures the limit is smaller and with higher pressures it is larger. If the pressure in the calorimeter is less than that of the atmosphere, for example, if the pipe *d* communicates with a condenser, the limit will be increased.

The calorimeter described is the first one made and it has been used just enough to show that consistent results can be attained. It is proposed to make others of different sizes and to make further experiments and comparison with other types of calorimeters.

CORRESPONDENCE.

THE IMPROVEMENT OF SABINE PASS.

To the Committee on Publications of the FRANKLIN INSTITUTE:

GENTLEMEN:—Permit me to add the following in reference to the improvement of Sabine Pass, in continuation of the correspondence in your number of May, 1888. Mine, of April 9, 1888, was not written with the purpose of questioning Prof. Haupt's veracity, its object was to correct a statement which, with its context, was entirely incorrect. I made objection to two items in the paragraph alluded to and repeated in Prof. Haupt's reply; the first item being the statement that the west jetty was built first, the second being that this west jetty had made a shoal on its east side.

With reference to the first, you are now informed that the perfect tense "was built" was not used to convey the idea of completeness. But Prof. Haupt quotes extracts from the history to support the expression that the west jetty was built first. He quotes the estimated cost of the entire work, $3,177,606.50. The details of this estimate, as shown in the reports, gave the cost of the west jetty as $1,412,493, and the reports further show that when the "work was commenced on the east jetty in March, 1885," only about $300,000 had been expended in connection with the west jetty—not much more than one-fifth its estimated cost. I submit then that the phrasing "was built" conveyed a most unfair impression of the conditions to readers of the paper in your April number.

I pass on to the second item, viz: that this west jetty made a shoal on its east side.

I gather from the context in the paper in your April issue, that it was

intended to establish, in regard to this jetty at Sabine Pass, that it had arrested material moving along the coast from the east to the westward and thus made a shoal on the east of the jetty, and what I have to say is in controversy with that proposition, and I definitely assume that Prof. Haupt in his reply sustains the affirmative.

The shoal "opposite the Clifton, and extending from the jetty 1,000 feet east, upon which the depth had decreased from 0·6 to 1·3 feet since 1881," was not formed of such westward-moving material arrested by the jetty, but was formed outside or below the convex bend in the jetty of material scoured from inside of that point by the exit current from the Pass. This deposit was favored by the fact that the shoal existed there about the Clifton before the jetty was built at all, and by the additional fact that the portion of the jetty above that point deflected the exit current to the eastward of the locality. In the latter respect, the deposit was under similar conditions to the deposits usually made below the convex bends in a stream. The curve of six feet depth moved to the eastward some 800 to 900 feet with a deposit of "from 0·6 to 1·3 feet since 1881!" But the width across the channel, eastward, to the six-foot curve was 1,750 feet greater than before, a condition, I submit, incompatible with the formation of a shoal, made by the jetty on its east side, as stated in the proposition.

Prof. Haupt adds the second paragraph on page 412 to fortify the statement that the jetty made a shoal on the east side. He omitted to add the succeeding lines of the report; I will do so presently.

In 1884, previous to this survey by Mr. Raymond, efforts were made by parties desirous of promoting a gigantic contract for Galveston harbor to cast discredit upon all operations under the Corps of Engineers; unfortunately, they attacked the work at Sabine Pass. They assiduously reported that the jetty had been carried away during the winter; also that it had made a shoal on its eastward side in the following spring. They condemned "commencing" the west jetty first, and affirmed that it had actually caused a decrease of depth upon the bar by arresting sand coming from the eastward. Prof. Haupt brings *sand* from this direction, too. It was known that a deposit of this material had recently formed upon the bar. As the bottom to the eastward for miles was known to consist of *mud*, these people brought this sand deposit from Calcasieu Bar, the nearest point where sand is found. I had occasion to visit Sabine Pass in the early summer. This sand deposit was found by me upon the summit or crest of the bar very compact, and, at the time, it was quite evident that where the channel had been was then shoaler than ordinary. In the detailed instructions to Mr. Raymond, he was required to determine the limits of this sand deposit; this was an important part of the evidence in regard to its origin. If it came from Calcasieu Pass, it should have left a trail from that direction. Mr. Raymond reports as follows upon this the second point of his instructions:

"The general character of the bottom elsewhere than on the sand area is a very soft mud, the exceptions being a few hard mud areas of limited extent and a very few isolated spots where shell was found." Then follows the quotation given by Prof. Haupt, and the report progresses as follows:

"Its northern limit* is found in a depth of 6·5 feet almost uniformly, while its southern edge is nearly coincident with the nine-foot curve.† *These facts seem to show that this sand was brought out of the Pass* by the exceptionally strong currents of the remarkably high water period of last spring, and deposited immediately in front of the entrance to the Pass upon the beginning of the outer slope of the bar just where the current receives its first serious check in passing over the crest of the bar." Why should Prof. Haupt omit to quote the lines above, especially those I italicize?

I know from my own experience, that sand deposit was found previously on the crest of the bar, and the survey on the later date shows that it had moved seaward. And the channel over the bar was shown by the survey to have deepened somewhat since the survey previous to the commencement of the jetty, and that between the six feet contours it had widened 1,750 feet. All this is on the eastward of the jetty, upon which side your readers have been informed the jetty made a shoal.

Prof. Haupt's explanation of the immense shoaling on the western side is all in the line of a westward movement of material which the jetty arrested until the shoaling to the eastward formed a ramp up which the material was carried and deposited then to the westward of the jetty. I use the word "material" (Prof. Haupt said sand), for I make no point of the fact that the deposit is not sand, it is mud.

It is true that the *outer slope* of the bar had moved seaward. The large quantity of material excavated from the inner slope and from the crest, necessarily created deposits on the outer slope where the exit current decreased in velocity. That deposit was made upon the front of the exit current over the bar and necessarily then on the eastward of the jetty. Had the jetty been "built" on the east side, this deposit would have been on the west of it, and would have been *made by the jetty* in the same sense. All the curves defining the channel were pushed to the eastward upon their eastward side. Had the jetty made a shoal as stated, the westward-moving "sand" would have crowded these curves of depth toward the jetty.

In the early summer of 1884, I conducted a series of soundings along and upon the jetty. These soundings were made expressly in reference to the alleged disappearance of the jetty. The soundings were always greater on either side of the jetty than upon the jetty itself, and the indications were that there was an excavated trench on each side, as might be supposed from the alternating direction of the overflow currents. (I tried to learn whether a special set of littoral currents existed at the flood or ebb across the line of the jetty and to determine their direction, and instructed Mr. Raymond accordingly. Forty-two observations, distributed along the line of the jetty and beyond its end, were made, and at both ebb and flood the currents across the line of the jetty were to the eastward or westward, according to the direction of the wind, in every case. The resultant westward set of the flood, I think, must be quite weak at this locality, inside of the outer extremity

* That is, its inshore limit.—T. T.

† All on the outer slope of the bar.—T. T.

of the jetty.) Mr. Raymond's report says: "Along the edges of the jetty and immediately beyond the end, the deepening produced by cross currents has been from three to four feet." The deepest fill to the westward is along that portion of the jetty where the curve of nine feet depth is close upon the jetty and where it pushed seaward 2,150 feet. In fact, Prof. Haupt's ramp has only existed in imagination; I do not urge this as material to the issue, for the ramp theory may be dispensed with perhaps, now that the deposit is learned to be mud.

It would have weakened the force of the statement that "the crest of the bar had been moved seaward 1,900 feet" somewhat, had the report been quoted; "the crest of the bar, as determined by a line joining the points of the six-foot curve nearest together has advanced into the gulf 1,900 feet." But "the points of the six-foot curve nearest together" were 1,750 feet farther apart on this new "crest" than on the old, and the depth was greater; what had been the crest was scoured away.

There are several allusions in Prof. Haupt's reply, which seem to relate more particularly to his theory of harbor dynamics, and I pass them by without entering into controversy.

The context of the paper, "Jetties for Improving Estuaries," and his summary relative to Sabine Pass, most unfairly made it appear that a certain principle, condemned as vicious, had been there adopted and persisted in, and his statement was incorrect. I combat the incorrect statement. I have no intention of questioning his veracity; I should be exceedingly sorry to doubt it. I think, however, that his errors are due to haste, perhaps, also, to eagerness, which caused him to seize upon sentences without proper examination of their neighbors or due consideration of their relations to those portions overlooked.

I desire to add for the information of your readers that it is not and never has been the intention to bring about the improvement of the Sabine bar by the use of one jetty; the plan requires two high jetties. The work, while anyone may express condemnation of it in advance, must eventually stand or fall with its results. Very respectfully,

THOMAS TURTLE,
Captain of Engineers.

WASHINGTON, D. C., May 21, 1888.

REPLY OF PROF. HAUPT TO CAPT. TURTLE'S COMMUNICATION OF DATE MAY 21, 1888, RELATIVE TO SABINE PASS.

To the Committee on Publications of the FRANKLIN INSTITUTE.

Gentlemen:—In the reply of Capt. Turtle, he alludes to two of my statements, which he desires to correct, the first being that referring to the west jetty being "built first;" the second, that it had made a shoal on its east side. To these points I have the honor to submit a brief reply.

The difference of interpretation as to the use of the expression "was built" is not of sufficient importance to warrant the space devoted to it, since

the quotations show that at the time of Mr. Raymond's report, from which the extracts were made, the *east* jetty had not been begun, and whatever changes had occurred were due to so much of the *west* jetty as was then built. I used the verb in the proper tense, the past, not the "perfect," as has been stated. It was not intended to convey the idea of completeness. The verb itself does not mean this, but a progressive development.

In speaking of the present jetties, as they exist to-day, although *not finished*, I do not believe it would "convey a most unfair impression" to say they *were built*, as indicative of their existence, just as I used the term "*was built*," for the west jetty in its then incomplete state, to express *its* existence. Should any one assert that the jetties now existing at Sabine Pass were "*not built*," I think the statement would be at once denied as untrue.

Moreover, in recommending the jetties at Sabine Pass, the Board of Engineers said, "the western jetty as proposed by Capt. Heuer, should be *built first* (but without shore openings) and its effects observed."

The work was conducted accordingly, and I cannot understand the sophistry which would object to my use of the verb to build, and not to that of the Board.

(2) The fact that the west jetty made a shoal on its eastern side, will not be doubted after a reading of the reports of Mr. Raymond. It is not *my* statement which Capt. Turtle attempts to explain, but that of his own engineer, who says: "The line of deepest water over the bar has moved somewhat to the eastward by the formation of a shoal opposite the Clifton and extending from the jetty 1,000 feet east," etc. The point Capt. Turtle desires to make refers more particularly, however, to the direction of the movement of the material of which this shoal was composed, and he quotes some additional statements of *opinions*, and asks, "why should Prof. Haupt omit to quote the lines above," etc. In reply I would submit that my entire original reference to this work was of necessity very short, and the quotation I made covered but two lines. It was, therefore, impossible to say all that the report contained. I merely called attention to a few salient facts. The quotation from Mr. Raymond, which Capt. Turtle makes, is an *opinion* expressed in rather dubious terms, and not an observed fact, and as I did not endorse it, I did not quote it, for I believe the material of the shoal to have come chiefly from the eastward. (I used the term "sand," as Capt. Turtle has supposed, inadvertently, for material, although Mr. Raymond calls it sand.) The importance of the changes that are so minutely detailed in the reports will be better understood from the following statements of the character of the bottom as given in Major Howell's Report of February 4, 1875, containing this extract from a report by Lieutenant Smith, U.S.E., made as early as February 15, 1853:

"Although the charts represent the bar as having but a little over five feet at low water, yet, on account of the softness of the mud, a steamship can readily pass drawing ten feet. In case of a southeast blow, it would be safe to venture over with a draught of ten feet. It is asserted that a vessel drawing twelve feet of water has crossed the bar in a blow."

Again, in the plan proposed by Major Howell for improvement, it was intended that "the material * * be carried to the *westward* a distance of at least half a mile, and dumped in from six to fifteen feet deep, so as to form a ridge to cut off sand that may drift from that direction [illegible] excavation. It is thought that this channel may fill so slowly from material washed in from its *eastern* side as to only make occasional dredging necessary to maintain it."

What is the experience?

The report of 1885 says: "In 1878, a channel, 12 feet deep, was dredged across the bar; another was dredged in 1880; both soon refilled." * * "The amount of money spent * * aggregated about $167,000."

These quotations show the recognized or suspected existence of littoral drift in both directions. It is not stated whether the cuts were filled by material from the Pass or from the adjacent shoals, neither is it important. The fact remains that the material is very mobile and that there is a lateral movement, the resultant of which I believe tends to the westward along this portion of the coast. It does not follow from this that violent southwest gales might not move sand eastwardly—to be returned by opposing storms.

That this sand would lodge on the outer or *up-hill* slope of the bar, if from the outside, rather than on the inner or down-hill slope, is natural.

My belief in this movement is founded upon such statements as these taken from Major Heuer's report of January 28, 1882:

"The bar at Sabine Pass is composed of a sticky, soft, blackish-blue mud to a depth of thirty feet." * * "The bar is probably a drift and wave bar and is certainly not a delta bar. * * * It is thought that the mud of which this bar is composed is eroded from the soft alluvial soil forming the coast for several hundred miles to the eastward, and is brought here by the wind waves and tidal currents. * * * We are, therefore, almost justified in stating that the bar is composed of soft mud to a depth of thirty feet below the water surface, as no traces of clay, sand, nor shell were found. * * * It was found that the flood tide in its first quarter, and sometimes extending nearly through its second quarter, came in on the Louisiana (east*) side; * * the current would frequently run out on the Texas side for two hours after the tide had commenced to run in on the Louisiana side. The ebb tides acted almost exactly opposite. The first of the ebb current was always on the Texas side," etc. * * * "Outside of Sabine Pass there is an undoubted littoral current whese general direction is from the east towards the west."

It would seem from these physical conditions that the conclusions as to a resultant westward drift are more than probable, and as it has been nowhere stated that a deposit or pocket of *sand* exists in the Pass or lake basin whereby to account for that found on the bar, the omission of a doubtful opinion as to its origin cannot have been a serious matter.

The references to the opposition of Galveston and to the trenches on both sides of the jetty, cut out by the cross currents due to the submerged condition of the work, appear to me irrelevant, and hence to require no answer.

The above quotations from Major Heuer's report do, however, appear to

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* L. M. H.

sustain fully my "theory of harbor dynamics" to which Captain Turtle has alluded. Respectfully submitted,

LEWIS M. HAUPT.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, *June 7, 1888.*

REPORTS OF THE COMMITTEE ON SCIENCE AND THE ARTS.

THE BACHE SAFETY CAR HEATER.

[No. 1383.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to which was referred for examination

MR. R. MEADE BACHE'S SAFETY CAR HEATER,

Report: That the object of the invention is to provide a car heater that shall afford safety to the occupants of a railway car in the event of the overturning of the same. To accomplish this object, the inventor provides for the automatic extinguishment of the fire by means of water carried for the purpose in a reservoir forming part of the stove.

The principal features of construction are as follows:

The heater body is made of wrought iron, to insure ample strength against crushing, and its general form is that of a tubular boiler with a domed top.

The water reservoir forms an important feature, being firmly attached to the heater. The top is also fastened on by numerous screw bolts, and the orifice through which the water is admitted is closed by a disc which screws into the top. The whole is so firmly fastened that it cannot be detached without violence.

The smoke-pipe issues from a strong steel dome, and suitable provision is made to prevent the escape of coal from the smoke-vent, by a peculiar construction of the flue inside of the top of the heater. As an additional precaution, there is also provided a grating to receive the coal, placed inside the smoke-flue.

The door is strongly made, and of the same material as the heater body, especial care being bestowed upon the locking

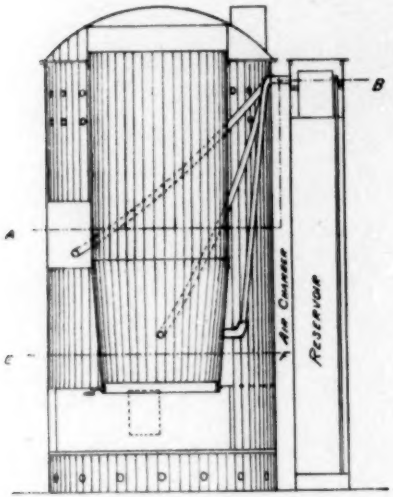
mechanism to assure ample security. The lock is so devised, as an added precaution, that the key cannot be withdrawn therefrom until the door is actually locked. The presence of the key in the lock will, therefore, be a "tell-tale," insuring, to a certain extent, the vigilance of the attendant.

For the purpose of extinguishing the fire in the heater in case of an accident, which would overturn it, a system of pipes is provided, one end of which terminates in the water reservoir, and the other end in and around the fire-pot. These pipes are suitably arranged in connection with air nozzles, that when the stove is overturned the water from the reservoir will be ejected through the pipes upon the contents of the fire-pot, and will promptly extinguish the fire therein.

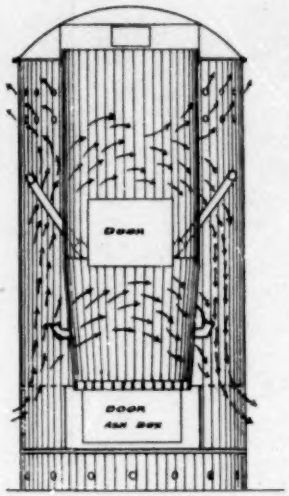
Around the bottom of the heater, with its base at the level of the ash-pit floor, is placed a flue running about the periphery of the heater. The ash-pit sides form its inner side, the outside casing of the heater forms its outer side, and its top and bottom extend across the space between the outside and inside casing of the heater. This flue is perforated all over the top with numerous small holes, to allow of the free passage of air through them. At the middle it is divided by a diaphragm. Air is received into the flue in the usual way, from the outside of the car, through one of the large openings in the base of the stove. Through the movement of the cars, the air is forced through the flues and warmed in its passage, and is distributed about the car by the ordinary channels along the side of the same. Between the heater body and the reservoir there is an air space, through which a portion of the cool air entering the flue is permitted to pass, thus maintaining a circulation of air which prevents the water in the reservoir from becoming unduly hot.

The above comprises the essential features of Mr. Bache's safety heater, and for additional details the Committee refers to a more elaborate description furnished by the inventor, which is attached to this report.

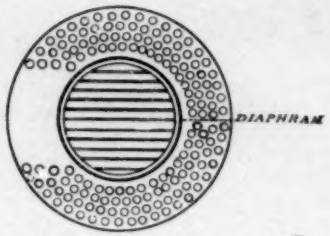
The Committee has had the opportunity of witnessing some experiments upon a full-size heater, of the form herein described, which satisfied the members of the substantial accuracy of the inventor's claims respecting the promptness and effectiveness of its fire-extinguishing qualities. In these experiments, the heater



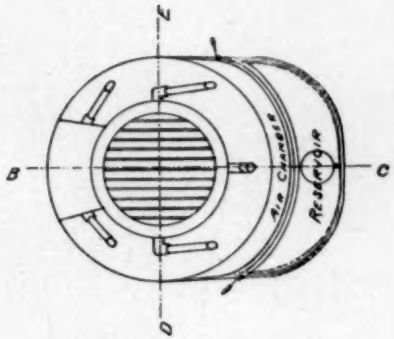
Section on line, *B.C.*



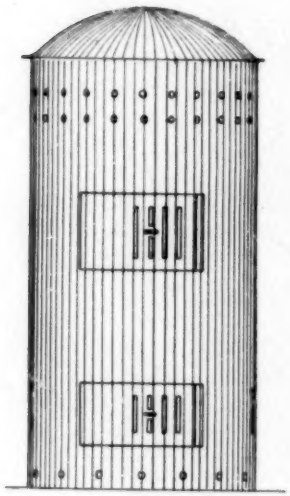
Section on line, *D.E.*



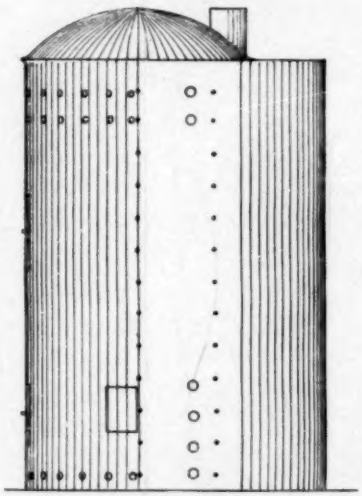
Section on line, *E.F.*



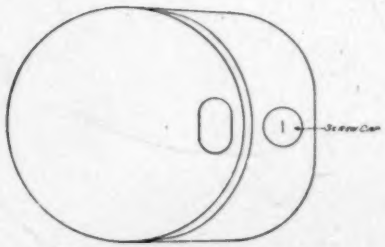
Section on line, *A B.*



Front Elevation.



Side Elevation.



Plan, looking down on Top.

was violently thrown upon its side, after a bright fire had been made in it, and the fire was entirely extinguished in less than one minute.

The Committee desires to give the applicant full credit for the very careful and thorough manner in which he has worked out each detail of construction. The car heater which he has produced, in the Committee's opinion, is distinctly superior to the car stoves in general use, in respect to safety, and it appears to be admirably designed and constructed to answer its intended purpose.

The Committee is aware that experiments have lately been made with the view of employing other means than direct fire for the heating of railway cars, and in passing judgment on this invention, does not wish to discourage them. So far as the Committee is advised, these trials have not passed beyond the experimental stage. It is well known to railroad men, also, that there are many circumstances and situations where systems of direct firing will have to be retained, even should the heating of railway cars by steam be made practically successful. The Committee commends the invention of Mr. Bache as highly meritorious.

CHAS. J. SHAIN,
CHAS. A. RUTTER,
RUFUS HILL.

Adopted April 4, 1888.

GEORGE A. KOENIG, *Chairman.*

APPENDIX.

DESCRIPTION OF A SAFETY CAR HEATER, DESIGNED BY R. MEADE BACHE.

[*Read before the* FRANKLIN INSTITUTE, *by* Mr. BACHE, *May 18, 1887.*]

Various devices have been suggested for safety car heaters—so-called chemical, and so-called automatic, arrangements—the former kind occasionally, the latter always, entering into the plan. It has seemed to me that water is the most reliable thing for the extinguishment of fire, and that a truly automatic and trustworthy arrangement could be combined with the use of water, if one could

dispense with the use of valves. Upon that basis, therefore, having dispensed with valves, I proceeded.

A large amount of water is not needed for extinguishing so small an amount of fire as that which can be contained in a car heater: less than a cubic foot suffices. In consequence, I settled upon a size of reservoir which should contain about three cubic feet of water; one for extinguishment of fire, the others to give sufficient head for the water. The steam generated by so small an amount of fire as that which can be contained in a car heater reaches the open air in the form of harmless vapor, similar in temperature, within a foot of its egress, to that of a Russian bath. Neither in quantity nor in quality can it be deemed even unpleasant.

The material adopted for the car heater designed by me is boiler iron, of the thickness of an eighth of an inch. The form of the apparatus is tubular, with a domed top. The top itself is of steel. This premised as to the general character of the heater, it remains to speak of the details of its construction. The doors are made of the same kind of material as that in the rest of the apparatus. They do not, when shut, depend for security upon the hinges on which they conveniently swing when open. They fit into the door openings as, in a general way, do those of fire-proof safes, and they are locked, in a general way similarly, by bolts of the height of the doors. The locks are fundamentally like those of combination locks; that is to say, there is a slot in a circle of metal into which the bolt fits; only, whereas in the combination lock there are many slots, in this case there is but one. The keys cannot be withdrawn unless the doors are actually locked. This precaution covers the contingency of neglect on the part of attendants to fasten a door, and puts it out of the power of passengers to open it.

The reservoir forms an integral portion of the heater itself, being firmly fastened to the heater, and having its top secured by numerous screw-bolts; and the orifice on top through which water is supplied to it is closed by a disc which screws into the top.

The smoke-pipe vent issues from a strong steel dome; and whereas ordinary smoke-pipe vents come directly outward from the heater, making, in fact, doors from which coal might escape, it is impossible for coal to escape from the smoke-pipe vent of this

heater, on account of the peculiar construction of the flue inside of the top of the heater. The floor of this flue lies between the outside and inside casings of the heater, its inner side is the continuation of the inside casing of the heater, and its other side, and top as well, are formed by the curve of the dome. The products of combustion enter the flue on the inner side, then pass in both directions around the flue, and then, exactly opposite where they enter, are liberated through a smoke-pipe passing vertically through the top of the dome. Therefore, for coal to pass through this flue to the outer air, it would be requisite, first, that the apparatus should stand on its head, that it should then, after falling to the horizontal position, receive a rotary motion around its axis, and finally, that it should, exactly when the coal had reached a position opposite the pipe-vent orifice, stand on its head again. An extra precaution has, however, been adopted to guard against this nearly impossible concatenation of circumstances. This consists in placing a grating in the smoke-flue, on both sides of the vent from the heater, so that whatever lodges there must stay there.

There is another factor noticed, but not yet fully described, included in the safety of the heater—that involved in its capacity of self-extinguishment. It may here be asked if it is not illogical to claim that a receptacle will, although subjected to violence, retain its fire, and yet to admit that it ought to include in its construction the capacity of self-extinguishment. It would be illogical if one should claim that under all circumstances a heater would retain its fire, but no such assertion is made here. The answer to a question which implies that such an apparatus must be so constructed as to enable it to resist the shock of any railway accident, is that railways themselves, cars and everything else included in them, are not so constructed. Nor, it may be added, is anything that man uses, even when his object incidentally contemplates resistance to force, so constructed that it can resist any force whatsoever of his accidental or designed creation. The weapons of a steel-clad knight, although primarily intended to be offensive, helped, in their defensive capacity, to guarantee the integrity of the mail itself. So, of a car heater, one may justly hold that it cannot be proof, through mere strength, against any possible railway accident, and yet that the water which the apparatus will throw in the

midst of an accident too severe for strength to avail may prevent the catastrophe of fire.

The nozzles of certain pipes, as may be seen from the model of the heater, enter the fire-pot itself. The nozzles of other pipes, as may also be seen, guard the door. The jets from the nozzles of the first set of pipes strike the fire in the very centre, and the jets from the nozzles of the second set of pipes strike the fire on top.

The upper system of air-tubes, on top of the reservoir, supplies the reservoir with atmospheric pressure through the 180° through which the apparatus may depart from the upright vertical position; and also supplies it with atmospheric pressure in any horizontal position which it may assume. As, on the contrary, when the reservoir is full, and the apparatus is in any position more or less upside down, through the other 180° of the circle, the upper system of air-tubes is incapable of acting as air-tubes, in those positions the single lower air-tube rising from the bottom of the reservoir supplies the place of the upper system.

Around the bottom of the heater, with its base at the level of the ash-pit floor, is a flue; continuous, but for the place where the ash-pit door comes, around the periphery of the heater. The ash-pit sides form its inner side, the outside casing of the heater forms its outer side, and its top and bottom extend across the space between the outside and inside casings of the heater. This flue is perforated all over its top with minute holes, so as to allow of the free passage of air through them. Finally, it is divided in the middle, at the rear, by a vertical diaphragm. Air is received into the flue in the usual way, from the outside of the car, through one of the large openings near the base of the heater; and through the propulsion of the air in its rear, from the movement of the car and from the rarefaction of the air entering the heater, the air in the flue up to the dividing diaphragm rises through the perforations on top of one-half of the flue into the space between the outside and inside casings of the heater. It then descends, after being heated between these casings, propelled through the perforations on top of that half of the flue which is beyond the diaphragm, and reaches, through the other large opening near the base of the heater, the ordinary channel which conveys it for warming purposes along the side of the car.

There is an air space of two inches between the heater and the

reservoir. A line of small holes, near the bottom of the side of the heater, on the cool air side of the lower flue, enters this air space. Therefore, when cool air is driven into this space by the motion of the car, a portion of it maintains a circulation of air between the reservoir and the heating part of the apparatus.

On top of the reservoir is a telltale indicating if the level of water has been allowed to become too low for the full effectiveness of the apparatus.

Just within the top of the reservoir is a diaphragm checking wave motion and indicating the height to which the reservoir should be filled.

Aside from the element of safety in this heater, and with reference now solely to its convenience for warming purposes, it may properly be stated in its favor that, whereas the present car heater discharges a large amount of heat from its sides, this one discharges relatively more from its top. This is an advantage in a car heater, as every experienced traveller will concede.

Inasmuch as the best heating for the purpose of bodily comfort and health consists in the delivery of a large volume of air drawn from a pure, outside source, and heated in transit, we have in a properly-constructed car heater, with hood and conduit for air and with vertical and lateral radiation properly adjusted through the mechanical means of a deflecting plate, the ideal of a heating apparatus for ordinary railway needs, each car commanding its own supply of heat at pleasure. Heating by waste steam from the engine is applicable to railways only within circumscribed limits. The general car heater must be constructed upon the plan of the past, so far as heating is concerned, but with the element of safety superadded to its convenience.

ZIEGLER'S PATENT TRESTLE AND SCAFFOLD SYSTEM.

[No. 1397.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 2, 1888.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination

GEORGE W. ZIEGLER'S PATENTED TRESTLES AND SCAFFOLDING SYSTEM,

Report: That they have examined the same and find that the invention consists in a metallic clamp adapted to embrace and

securely hold together the wooden portions of such structures, the legs and horizontal beam, and, without cutting away any portion subjected to the load, or impairing the strength of the wood, firmly holding the parts in correct position with each other.

This invention is the subject of United States Letters-Patent, numbered 318,154 and 362,914, dated, respectively, May 19, 1885, and May 10, 1887, the latter patent being for attachments to the former, rendering it applicable to the easy erection of secure platforms, stages and tables, and other structures intended for temporary use, and required to be compactly stored and conveniently transported and re-erected.

A third United States patent, numbered 327,427, and dated September 29, 1885, is for a modified form of the first; applicable to the building of temporary bridges and high scaffolds.

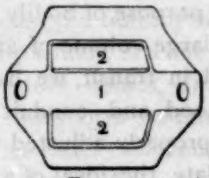


FIG. 1.

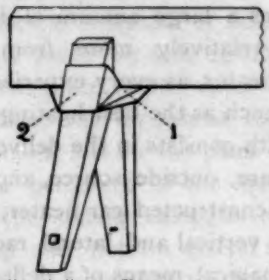


FIG. 2.

In addition to these patents, the inventor has also seven other patents, and applications for some others in course of preparation, for devices, embracing adaptations of his clamping inventions, to uses in articles of furniture for domestic purposes and stagings for accommodating public meetings. It will, therefore, be seen that the inventions are really a system of structures depending upon and embodying the clamping device, which we will now proceed to describe.

This consists in a band or socket, shown in the adjacent *Fig. 1*, having a flat bearing, 1, on which the horizontal beam, shown in *Fig. 2*, rests on converging sockets, open at the upper end, into which the legs of the trestle are inserted. In making these sockets, the properties of the material (malleable cast iron) have been carefully studied, and all abrupt, sharp, internal angles and thick places or parts avoided. It is well known that the interior metal of thick

parts in malleable castings does not contribute to the strength of the casting, but by shrinking or contraction weakens it. This shrinking occurs when the metal is first cast and is extremely hard and brittle. The ductile or malleable properties of the casting, being developed by subsequent treatment, do not mend the checks and cracks that form in the casting operation.

The wooden parts of the trestle are simply inserted in the sockets or clamps and are there held without recourse to other fastenings. The dressing or fitting required in the wooden parts is merely to cut one inclined surface on the side of the leg to rest against the beam, and to cut the base of the legs to a horizontal plane; all of the wood remains intact in the legs between

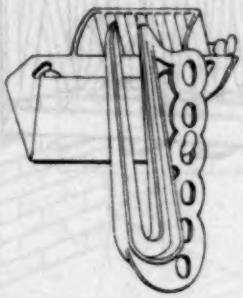


FIG. 3.

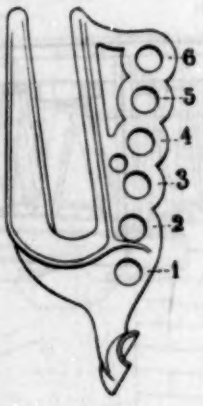


FIG. 4.

the socket clamps and the base, and all of it is efficiently used in sustaining the load.

These clamps are made in a variety of sizes adapted to different classes of work.

To some of the clamps are attached hooks, shown in *Fig. 3*, upon which a bracket, shown separately in *Fig. 4*, provided with a series of apertures at intervals of an inch, and slots open at the top of a width equal to the thickness of the boards used in flooring. The edges of the slot are bevelled, so that they impinge on the sides of the board; each of the apertures is numbered, so that by hooking the aperture with the number corresponding with width of the board, the boards placed on edge in the brackets

present their upper edges the same in the same plane as joists to support a flooring.

The trestles, made as described, are susceptible of assembling into bridges, as shown in *Fig. 5*, or as a scaffold, as shown in *Fig. 6*, which can be extended indefinitely in length and height, and may be braced by means of bracket-hooks, as shown in *Fig. 6*.

This form of the invention, as above described, has the following advantage over other systems of scaffolding: It utilizes the entire strength of the material; does not suffer any waste in taking down and re-erecting; is compact and convenient for storage or transportation; does not depend on the skill of workmen for its safe proportioning and proper erection; and the clamps being the

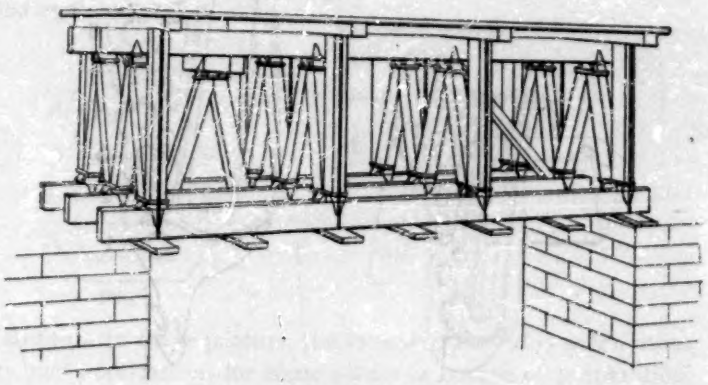


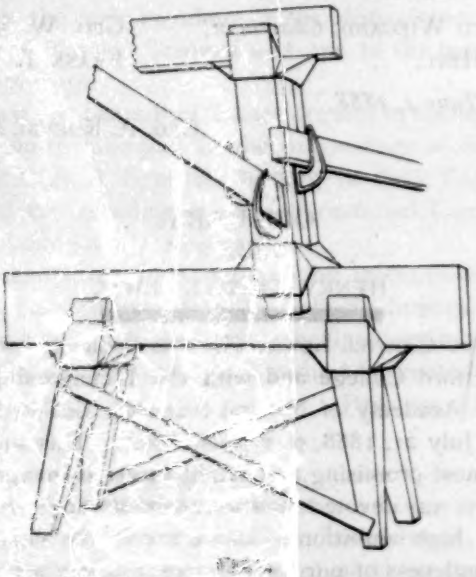
FIG. 5.

only parts requiring to be made from patterns in special factories and transported long distances, the invention can be used economically wherever sawed lumber is procurable; and, since by their form, they determine the angle of inclination of the parts of the wood-work to insure proper bracing effects, correct work in this important feature is enforced.

In another form of the trestles made by the same inventor, a different system of construction is involved; this is shown in the blue prints annexed to this report and consists of plates having projecting spurs which imbed themselves in the sides of the wood forming the beams and legs, and the plates are fitted so as to rest upon each other and permit the legs to fold in parallel position

with the beam, the parts being united by bolts passing through washers embracing the width of the leg strips, and provided with spherical seats against which the bolts and nuts hold, thus avoiding all other strain on the bolt than that of tension in the line of its axis. A test carefully made by the Bureau of Steam Engineering of the United States Navy shows the value and capacity of the invention for sustaining weight, a report of which is submitted with other documentary evidence.

The development of the invention, as shown in its application to various uses in domestic arrangements as well as in the arts, is



so fully shown in the patents and drawings appended that your Committee does not feel warranted in incorporating such a mass of detail in this report, but simply refers to the patent specifications and documents hereto annexed and named in an appended schedule.

Although it is generally well known that scaffolds have been made which were adjustable to different situations, and in which clamps were used to unite the sections of the uprights and braces, it does not appear that in any of them the bracing and clamping effects were attained by sockets embracing the different parts at their joints.

In conclusion, your Committee feels fully warranted in stating that the system of trestles and scaffolding submitted by Mr. Geo. W. Ziegler is deserving of recognition as of great merit, in that it economizes material, produces safe scaffolding structures easily procured wherever building materials are accessible, offers an effective means of diminishing the waste of lumber that has prevailed in building operations, and is susceptible of easy and immediate introduction in the arts, without specially training of workmen to accustom them to its use, and, upon its merit, justifies the recommendation of the award of "THE JOHN SCOTT LEGACY MEDAL AND PREMIUM."

S. LLOYD WIEGAND, *Chairman*,
H. R. HEYL,
GEO. W. WILSON,
FRANK P. BROWN.

Adopted June 4, 1888.

GEO. A. KOENIG, *Chairman.*

OBITUARY.

HENRY CARVILL LEWIS.

Prof. HENRY CARVILL LEWIS, who was connected with the faculty of Haverford College and with the Professorship of Mineralogy of the Academy of Natural Sciences, died in Manchester, England, on July 21, 1888, of typhoid fever. This sudden termination of a most promising and bright career is inexpressibly sad.

Prof. LEWIS was devoted to science for science's own sake, and added to the high ambition of conquests in the field of original research a singleness of purpose and an industry which are given to but very few, even of those who choose the Laufbahn of pure science. His work, in connection with the glacial geology of Pennsylvania, and the post-tertiary history of the neighborhood of the city, will remain, in the published volumes of the Second Geological Survey of Pennsylvania (C_5, C_6 and Z), as enduring monuments to him. His interest in the questions which the modern method of microscopical lithology has raised was profound, and if his life had been prolonged he would assuredly have taken rank with the more prominent American petrologists. As a professor his energy and enthusiasm was infused into his pupils, few of whom, however indifferent at

the outset, could resist the influence which he exerted. His field rambles with his classes were always looked forward to by the participants with pleasure and always well conducted.

He was the first to bring before the Academy of Natural Sciences, in 1883, the proposition to hold a joint meeting of the British and American Associations for the Advancement of Science in Philadelphia during September of the following year, and as one of the local secretaries of that meeting he contributed largely to the success of the undertaking. His lectures and expositions in learned societies were always characterized by clearness and fluency to which an agreeable voice and a fine presence lent force.

He was one of the early members of the Mineralogical Section of the Academy of Natural Sciences and one of the most valued contributors to its work.

During the last few years Prof. LEWIS studied in Germany, and it was his intention to take part in the proceedings of Section C (Geology) of the B. A. A. S. at the meeting in Bath, England, as well as to attend the meeting of the International Congress of Geologists in London shortly afterwards.

His loss is sincerely mourned, not only by scientific men generally in this country, among whom he held an honorable place, but by the wider circle of friends and acquaintances to which he was known chiefly as a cultivated and earnest promoter of many forms of educational progress. PERSIFOR FRAZER.

WILLIAM HELME.

Mr. WILLIAM HELME died at Strafford, Pennsylvania, on June 12th, from the effects of a severe stroke of paralysis received on the morning of June 3, 1888.

Mr. HELME was born in Dumfries, Scotland, on the 25th of April, 1824, and when a child accompanied his parents to this country, settling in Philadelphia.

He learned the trade of machinist in the shops of the Baldwin Locomotive Works, and whilst there was offered the position of Superintendent of the Gas Works at Trenton, N. J., which he accepted, this being his introduction to the business which he most directly followed during the remainder of his life. Later he completed the erection of the gas works in Augusta, Ga., and remained

there sometime as Superintendent. In 1853, he resigned the position and associating himself with two prominent citizens of Augusta entered the lumber and saw-mill business.

A site was secured at Brunswick, Ga., and on it they erected the largest saw-mill then in the South. This venture proved disastrous, as but three months elapsed after the completion of the mill when it was struck by lightning and entirely consumed by fire. It was never rebuilt and the old stack was a well-known landmark in the vicinity until within the past few years. After this misfortune, he returned to the gas business and secured the contract for the building of works at Winchester, Va., and after their completion he constructed works at various places in Pennsylvania and the South.

In 1856, he built the works at Atlanta, Ga. These works were rebuilt immediately after the war, having been almost entirely destroyed by General Sherman's army.

To these works Mr. HELME gave most of his attention, having held from the beginning the largest individual interest in them. He ably guided the company through many trials, and five years ago successfully solved the problem of dollar gas, continuing to pay fair dividends without interruption; and his careful management leaves the company in a stronger position at present than at any other period of its history.

In 1865, he became interested in certain mining operations in Arizona, and went there to erect the machinery, etc. This was before the days of railroads west of the Missouri, and he went to Arizona, and continued on to the Pacific on horseback.

On his return from the West, he engaged with the firm of A. Whitney & Sons, car-wheel manufacturers, in the position of Superintendent, and continued with them until 1872, when he entered the firm of Harris & Brother, manufacturers of gas-meters, which firm was succeeded by that of Helme & McIlhenny, in which he was senior partner at the time of his death.

Mr. HELME combined the sterling and conservative qualities of his native land, with the activity and business energy of the country of his adoption.

He was an active member of the American Gas Light Association from its formation.

He was, at the time of his death, one of the oldest members of

the FRANKLIN INSTITUTE, having been elected in 1844, and was and had been since the year 186[illegible] a member of the Board of Managers. At all times he manifested a lively interest in the affairs of the INSTITUTE, and rendered valuable service upon its Committees.

He was a member, and for some years the President, of the St. Andrew's Society of Philadelphia; a manager of the Hayes Home for Aged Mechanics, and was identified in an unobtrusive way with other benevolent and charitable institutions.

ISAAC NORRIS, M.D., EDWARD LONGSTRETH, WM. H. WAHL.

SCIENTIFIC NOTES AND COMMENTS.

ENGINEERING.

NATIONAL PUBLIC WORKS.—The proposed legislation, having for its final aim the combination into one department of the entire scientific work of the Government, is worth more than a passing notice from those who are not interested in the matter, either as civil engineers looking for Government work, or those in the Government employ interested in retaining in their control the technical work done by the different bureaus of the different departments of the Government. As an entering wedge, the Council of Engineering Societies on National Public Works has had bills introduced in both Houses of Congress to establish a Bureau of Harbors and Water-ways under the War Department. As this bureau is to be the basis or nucleus of the new department, the bills are interesting. This council is composed of representatives from the various engineering societies in the United States, representing over 3,000 members. There is no doubt but that the sentiments of this council are the expressions of opinions generally entertained by civil engineers, but in this 3,000 men there are many who are not civil engineers, and who have probably not, except in a general way, given the matter any attention. Representation of a society at a meeting of a council of this kind is generally brought about in this way. An invitation is sent to an engineering society, composed of, say, 200 members, to send a representative to the meeting of the council. It is read by the secretary at the next meeting of the society, at which, say, thirty members are present. A member is appointed to represent the society, and at the next meeting of the council the society is represented *by proxy*, and 200 more civil engineers are in complete accord with the views of the council.

In a pamphlet, published March, 1888, the aims of the council are set forth in the following paragraph:

"It is proposed to create a system which, while securing thorough administrative responsibility, will at the same time utilize, without repression, all the brains of the personnel—a system, the vitality and usefulness of which is the aggregate expression of the corps rather than of its chief."

The methods by which this is to be done are set forth in the bill, a synopsis of which is given later. The working of the scheme will be often like the following: A. B., Assistant Engineer, in charge of the work at X. Y., finds that certain changes in the methods used (which were originally formulated by a clerk in the office of the Department Engineer) would facilitate work, and sends a communication to C. D., Resident Engineer, stating proposed changes, giving cost, etc. C. D., knowing the nature of the work done, approves of A. B.'s recommendations, and refers the communication to E. F., Division Engineer. E. F. forwards to the Department Engineer, who knows that C. D. is not much of an engineer anyway, and has never heard of A. B., who is not an officer, and, of course, cannot know as much as his clerk, and the recommendations are not approved, and thus the brains of the personnel are utilized. It is not at all likely that the new arrangement will be as successful as the present one in taking advantage of the recommendations of those actually engaged in the work.

While the council wisely remarks that "in great engineering enterprises it is prerequisite that the chief shall not only be an able man, but shall have had a preliminary training and an actual experience in the details which he is called upon to supervise," it does not follow that the chief of this new department will have to be such an officer. While it still remains a bureau, there will be many technical questions which he will be called upon to finally decide, and which will be decided and the work finally carried out as indicated by one man, which is to be deplored (see first quotation); but upon reaching the dignity of a department, the chief need no more be a civil engineer than the Secretary of War need be an expert in ordnance or the Secretary of the Navy in ship building.

Great stress is laid upon the fact that the ranks will be recruited from men of special education, such as is now provided by several engineering schools. This is curious, in view of the work done at the Military Academy and at many of these schools. Anyone aware of the amount, and especially the quality of the work done at the different institutions, would never for an instant attempt to make a comparison, as the work at the Government schools is far in advance of that done in all but one or, at most, two of these engineering schools. As far as technical knowledge of the kind necessary for use in river and harbor work goes, where is there a corps of instructors better fitted to teach it to-day than at West Point? and where are students graduated from any institution with a broad knowledge of engineering who are any more capable of doing this work than those graduated at West Point?

The fact that the engineers of the army are well fitted, both by education and training, for the work they have to do, is admitted in the proposition to transfer bodily one-half of this corps of the army to the corps of civil engineers. It therefore seems somewhat contradictory to talk in one place of special training, which by inference engineers of the army do not have, and in another to admit that one-half the corps would be transferred and "none need be disbarred."

The council also says, that "under a well ordered system, requiring sev-

eral tests for fitness and experience, none but deserving men will reach the grade of division engineer."

It cannot be believed that any system of examination will exclude non-deserving men from promotion, and where promotion is principally by seniority (after examination), it will be found nearly impossible to get rid of an incompetent man. Incompetence is about as hard a charge to *prove* against a man, before a court composed of his associates and many times his friends, as could be preferred against him, and it is doubtful whether more dismissals would be made for this cause than now take place in the army or navy for the same cause, and the new corps being recruited from the graduate of engineering schools would undoubtediy have far more of this class than either the military or the naval services. At present, when a man has shown his incapacity for the work he is doing, a simple order from the Department is issued, and he no longer is employed on the work. Under the new scheme he would continue expending Government funds until he retired, or is put upon half pay.

The provision allowing the employment of expert engineers outside the new corps is surely unnecessary. A body of eminent men, especially trained in river and harbor work, using all the brains of the personnel, could hardly need the assistance of the few civil engineers of experience in river and harbor work who would be left in civil life after the 600 are members of the corps.

While the present bill would take care of many engineers now out of the Government employ, at the end of one generation the present condition of affairs would again exist, and the new generation of civil engineers could, with as good grace, and would make the same charges of incompetency and prodigality against the Corps of Civil Engineers that are now made against those engineers at present in charge of the work.

The council has evidently taken it for granted that there is but one best way of carrying on the great operations of the governments of all countries, and that if the best parts of the systems of other countries be formulated into a general plan it will be the best one for this country. Until political advantage and the public good are synonymous terms, any plans based upon the latter solely must give way for the former.

While there is no question but that improvements can be made in the methods of improving rivers and harbors, it would be well to be sure that proposed changes will probably result advantageously before making them. The proposed legislation will undoubtedly result in advantage to the civil engineers, but what advantage can result to the country or to the work to be done is not so clear.

The following is a summary of the bill as recommended by the Council:

SECTION 1 provides for the establishment of a Bureau of Harbor and Water-ways under the War Department, to be officered by the Corps of United States Civil Engineers.

SEC. 2 defines the limits of the work of the Bureau.

SEC. 3 provides that no appropriation shall be expended on a work unless

it is enough to complete it, or unless provision shall have been made for funds. Appropriations are to be available until used.

SEC. 4 provides for reports and financial statements.

SEC. 5 allows Secretary of War to do work by contract under certain restrictions.

SEC. 6 provides for personnel:

Officers.—1 chief engineer, 4 associate chief engineers, 11 department engineers, 50 division engineers, 100 resident engineers.

Not officers.—200 first assistant engineers, 250 second assistant engineers.

SEC. 7. Officers are to be appointed by the President by and with the consent of the Senate. All except chief are to be appointed after examination. First and second assistant engineers are to be appointed by the Secretary of War.

Every third vacancy in first assistant, fifth in resident and tenth in division engineers may be filled from outside the regular service (after examination).

SEC. 8 Promotion by seniority after examination. Seniority determined by date of commission or appointment.

SEC. 9 gives Secretary of War power to determine number of vacancies to be filled by appointment or promotion, and practically gives him power to institute inquiry and trial courts.

SEC. 10. Pay.—Chief engineer, $10,000 (pay of army officer of least rank allowed to do the work, $5,220).
Associate chief, $7,500 ($4,736).
Department engineer, $6,000 ($4,036).
Division engineer, $4,000 ($3,232).
Resident engineer, $2,700 ($2,376).
First assistant engineer, $1,800.
Second assistant engineer, $1,200.

Secretary of War also allowed to employ special engineering counsel and engineers to do the work of first and second assistant engineers temporarily.

SEC. 11. All officers retire at sixty-five years of age on half pay.

SEC. 12. Members of this corps are not to be employed upon work outside the Bureau except on the President's orders.

SEC. 13 provides that in establishing the corps, the engineers of the army may be assigned in certain proportions and fixes their rank.

SEC. 14 provides for the return of these officers to the army work or permits of their permanent membership of the new corps.

SEC. 15 provides for a commission to formulate rules and regulations, and to nominate officers.

SEC. 16 provides for the division of the country into departments.

SEC. 17 provides for annual reports on the needs of the country.

SEC. 18 provides for temporary retirement on half pay of those not actually needed, and allows officers *so retired* to accept outside professional work.

SEC. 19 provides for estimates.

SEC. 20 repeals conflicting statutes, and vacates and abolishes all other offices than those provided for. H. W. S.

THE REORGANIZATION OF PUBLIC CIVIL WORKS.—The Cullom-Breckinridge Bill for the reorganization of the civil works of the Government, in connection more especially with the river and harbor improvements, has been introduced in both the Senate and House of Representatives, read and referred to their appropriate committees. The measure is one of great national importance, since the present method of conducting our civil works is one which has grown up with the development of the country, and is not even based upon a fixed organization. It is open to serious defects in the methods of securing the appropriations for urgent works, insufficient funds to complete them rapidly or to maintain them after having been commenced, lack of responsibility for methods and results, frequent changes in the personnel of the corps and, in times of war, there may be a total suspension of all work.

There is no public improvement that we can imagine of greater benefit to all classes of individuals than that of improving the water ways, whereby the cost of transportation may be completely controlled and the market range of either raw material or manufactured product be extended. To promote these benefits and remove these defects is the object of this bill, and yet the conservatism of the existing régime is heard protesting against it in the interest of a method which pours out the public funds for work which must soon be rebuilt, because not protected, and places the public patronage in the hands of politicians.

There is no charge nor implication of dishonesty nor incompetency on the part of the Government military engineers who are performing these duties, as on detached service, and there is no precedent for this condition of affairs in foreign countries, where, although an ample military organization exists, the civil works are placed entirely under the control of a civil corps, specially trained and qualified for the purpose. The bill now in Congress is not prepared in the interests of a class of professional specialists, but to best promote the general welfare and commercial prosperity of the entire country. Its peculiar features and the means by which these ends are proposed to be attained, are admirably stated in Senator Cullom's contribution to the May number of the *Forum*, entitled "Appropriations for Public Works."

The provisions of the bill have been well sifted by discussions in technical papers and societies, and a few modifications made to meet the minor objections which have been made, until it is believed to be in the best possible shape. It provides for a subdivision of the country into ten or eleven topographical basins or departments, over each of which there shall be a permanent chief or department engineer, who will again subdivide into districts with local officers who are to be held individually responsible, and to be subject to promotion based upon relative merit. There will be a chief executive officer and an advisory council, and all plans, projects and estimates shall be forwarded and approved through the authorized channels to Congress. Appropriations shall be made for the completion of the project, payable by instalments as required, and all larger works will stand upon their merits and

importance. For continuous operations, such as dredging and snagging and for lesser works, a general bill will be prepared, and the aggregate amount will be divided pro rata between the departments. H.

CHEMISTRY.

THE EMPLOYMENT OF MAGNESIUM POWDER for photographic purposes by blowing it into the flame of a lamp, seemed positively void of any danger of serious explosion; but recently in employing the bottle containing the powder with two tubes (as described in this JOURNAL, **125,** 262) and a pneumatic bulb, upon releasing the latter from pressure the flame was drawn back into the bottle and produced a violent explosion. This source of danger can, of course, be easily eliminated. C. F. H.

PHOTOGRAPH OF THE HUMAN EYE BY MAGNESIUM FLASH LIGHT.—By means of the magnesium flash light a photograph was taken (*Nature*, **38,** 13), at the suggestion of Du Bois Reymond, of a normal eye, life-size, after a quarter of an hour's rest in a completely darkened room, showing the pupil of the eye fully dilated, as its reaction does not begin until after exposure. Hitherto the effect of complete darkness on the pupil could only be observed by the light of the electric spark, but these photographs permit of measurements. C. F. H.

A DIRECT METHOD FOR DETERMINING THE ABSOLUTE TIME OF INSTANTANEOUS PHOTOGRAPHIC EXPOSURES, and the rate of movement of the shutter, is given, with illustrative examples, by Wallace Goold Levison in a paper read before the New York Academy of Sciences, January 16, 1888, and seems susceptible of refinement that may adapt it to other scientific purposes. It is essentially a tuning-fork method. A beam of sunlight from a heliostat, after falling upon a mirror attached to the prong of a tuning-fork, is condensed to a brilliant point upon a sensitive plate, or, still better, a sensitive film, attached directly to the moving shutter. The vibrating fork causes the spot to describe a sinusoid on the moving shutter, bounded at each end by transverse straight lines, which appears on development. The number and proportionate widths of the complete undulations, with the frequency of the tuning-fork, afford the data for computing the time of exposure and the rate of motion, which latter varies during the motion, when a retractile spring is employed; the motion being accelerated, as the tracing shows, even when the shutter moves vertically upward. A rotating disc with sensitive film can be used instead of the sliding shutter for certain kinds of measurement. Among the applications of the method, the writer suggests the timing of electric discharges, of the magnesium flash, and to astronomical photography. Due credit is given Londe for his method, from which this differs in the direct action of the light upon the moving shutter, without intervention of lenses. C. F. H.

INSOLUBLE GELATINE FILMS AS A SUBSTITUTE FOR GLASS IN EMULSION PHOTOGRAPHY.—Alfred Stieglitz in the *Photographische Mittheilungen*, quoted in the *Photographic Times*, **18,** 141, gives the following account of

the manner of preparing the vergera gelatine films of which so much has lately been written:

As a carrier of the sensitive emulsion the purest gelatine is used, which is hardened with potassium bi-chromate nearly to insolubility; then boiled again until liquid. Plates are coated with it, and the films are dried in a dust-free apartment. When quite dry these plates are exposed to light, after which the gelatine is found to be hard and insoluble in boiling water.

To remove the yellow tint of the plates, caused by the bi-chromate, they are washed in a moderately strong acid bath. After drying again, they are coated with the sensitive emulsion. When hard and dried in the usual way, the films are stripped from the glass and are then ready for exposure.

The subsequent treatment is the same as that with a glass plate, only after the films have been thoroughly washed, they must be laid for fifteen minutes in alcohol to effect a quick and uniform drying. W.

GEOGRAPHY.

INTERNATIONAL GEOGRAPHICAL CONGRESS IN PARIS.—The Geographical Society of Paris has decided to take advantage of the presence of the many savants who will attend the Universal Exposition in Paris next year, by calling together a Geographical Congress, which will meet next August a year. The sections into which the Congress will be divided are six, as follows:

(1) Geodesy (Hydrography and Topography).
(2) Physical Geography.
(3) Economic and Commercial Geography.
(4) Historical and Ethnographical Geography.
(5) Pedagogical Geography.
(6) Cartography.

The usual arrangements are adopted for the payment of admission dues and the receipt of the published proceedings of the Congress, to which will be added a commemorative medal.

The French Geographical Society, which has taken the initiative in this matter, suggests that each Society represented at the Congress shall produce a catalogue of those investigations, publications, etc., of its own country, which have most contributed to the progress of the science of geography during the last century.

These catalogues published together, each with the names of its authors, will form a most valuable volume of reference for the science.

The circular is signed by the President of the French Society, the President of the Central Commission, and the General Secretary; the Vice-President of the Central Commission, and the General Secretary of the Society of Commercial Geography. These latter facts are only mentioned here to remark that out of all the signatures but one of them is clearly legible, and two are absolutely illegible. It seems as if all over the world the legibility of handwriting is decreasing as knowledge of the arts and sciences increases. There are few of the smooth and unmistakable handwritings of a century ago.

A Geographical Congress, which was to have met in April, was postponed on account of the death of the Emperor William I. P. F.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE DURING JUNE AND JULY, 1888.

Alabama. Reports of the Railroad Commissioners for 1886 and 1887.
Presented by the Commissioners.

Allen, L. F. Rural Architecture. New York, 1856.
Presented by Mr. S. H. Needles.

American Institute of Mining Engineers. Index Vols. 1 to 15.
Presented by the Institute.

Anvers. Port de mer. Bruxelles, 1885. Presented by Mr. L. S. Ware.

Association Amicale des Anciens élèves de l'école centrale des Arts et Manufactures. Annuaire 1832–86, 1832–87. Paris, 1887–88.
Presented by Mr. L. S. Ware.

Baltimore. Fifty-ninth Annual Report of the Board of Commissioners of Public Schools for 1887. Baltimore, N. D. Presented by the Board.

Banquet to Commemorate the Framing and Signing of the Constitution of the United States. Philadelphia, 1888.
Presented by the Committee on Arrangements.

Beedell, E. The British Tariff for 1856–57. London, 1856.
Presented by Mr. S. H. Needles.

Board of Supervising Inspectors of Steam Vessels. Proceedings of the Thirty-sixth Annual Meeting. Part 1. Presented by the Board.

Booth, J. C. Phonographic Instructor. Philadelphia, 1850.
Presented by Mr. S. H. Needles.

Brooklyn Library. Thirtieth Annual Report for 1887.
Presented by the Library.

Buffalo City Water Works. Nineteenth Annual Report for 1887.
Presented by the Chief Engineer.

Bureau of Statistics. Quarterly Report. No. 3, 1887–88.

Statistical Abstract of the United States. Tenth Number. Washington, 1888.
Presented by the Bureau.

Calhoun. Monument at Charleston, S. C. History. Charleston, 1888.
Presented by the Ladies' Calhoun Monument Association.

California. Annual Meteorological Review for 1887.
Presented by Sergeant J. A. Barwick.

Carriage Monthly. Vol. 17, 1881–2.
Presented by Messrs. Ware Brothers, Publishers.

Census United States. Tenth. Vol. 10, Part 2 and plates.
Presented by Hon. John I. Mitchell.

Central Pacific Railroad. Argument of Creed Hammond.
Presented by Central Pacific Railroad Company.

Chevallier, M. A. Dictionnaire des Alterations et Falsifications des Substances. Paris, 1854–55. Presented by Mr. R. A. Fisher.

College of Science, Imperial University Japan, Journal. Vol. 2, Part 1.
Presented by the College.

Commercial Exchange, Philadelphia. Thirty-fourth Annual Report.
Presented by Mr. C. Ross Smith, Secretary.

Cooper Union. New York City. Twenty-ninth Annual Report, 1888.
Presented by the Cooper Union.

Coupland, S. Personal Appearances. New York, 1879.
Presented by Mr. L. S. Ware.

Cox & Co. List of Persons who have been Advertised for in Proceedings in the Court of Chancery. Presented by Mr. L. S. Ware.

Department of Agriculture United States. Report for 1887. Botanical Division. Bulletins Nos. 5 and 6. Report of the Statistician. Nos. 51 and 52. Presented by the Department.

Engineers' Society of Western Pennsylvania. Papers and Discussions to May, 1888. Presented by the Society.

Geological Survey of India. Memoirs. Palæontologia Indica. Ser. 13, Vol. 1, No. 7. Presented by the Survey.

Hargreaves, W. Our Wasted Resources. New York, 1879.
Presented by Mr. L. S. Ware.

Hydrographic Office. United States Pilot Chart of the North Atlantic Ocean, June and July, 1888. Presented by the Office.

Institution of Civil Engineers. Minutes of Proceedings. Vol. 92.
Presented by the Institution.

Jaeger, G. Sanitary Woollen System. London, N. D.
Presented by Mr. L. S. Ware.

Jousse Commentaire sur l'ordonnance du Commerce. Paris, 1841.
Presented by Mr. S. H. Needles.

Kansas. Crop and Weather Bulletin. For April and May, 1888.
Presented by the State Board of Agriculture.

Kansas State Board of Agriculture. Report for the Quarter ending May 31, 1888. Topeka, 1888. Presented by the Board.

Kansas. Third Annual Report of the State Board of Health for 1887. Topeka, 1888. Presented by the Board.

Laughenhove, R. van. Armements en Europe et en Amérique. Bruxelles, 1888. Presented by Mr. Eugene H. Cowles.

Liebig, J., J. C. Poggendorff und F. Wohler. Handwörterbuch der Chemie. Braunschweig, 1842–61. 9 V. Presented by Mr. R. A. Fisher.

Literary and Philosophical Society of Manchester. Proceedings. Vols. 25 and 26. Memoirs. Vol. 10. 3 S. Presented by the Society.

Locomotive, The. Vol. 8. 1887.
Presented by the Hartford Steam Boiler Inspection and Insurance Co.

Louisiana Biennial Report of the Board of Health. Baton Rouge, 1888.
Presented by the Board.

Löwig, Carl. Chemie der organischen Verbindungen. Braunschweig, 1846–7. Presented by Mr. R. A. Fisher.

Macfie, R. A. Copyright and Patents for Inventions. Edinburgh, 1879 and 1883. Presented by the Author.

Massachusetts. Charitable Mechanics' Association. Report of Sixteenth Exhibition. Boston, 1888. Presented by the Association.

Massachusetts First to Third Annual Reports of the Board of Gas Commissioners for 1885-1887. Presented by the Board.

Massachusetts. Nineteenth Annual Report of the State Board of Health. Boston, 1888. Presented by the Board.

Massachusetts State Agricultural Experiment Station. Bulletin No. 29. Presented by the Station.

Mercantile Library Association of New York. Sixty-seventh Annual Report of the Board of Direction for 1887–1888. New York, 1888. Presented by the Association.

Meteorological Council Royal Society London. Hourly Readings. Part 3. 1885. Quarterly Weather Report. Part 3, 1879. Presented by the Council.

Meteorological Department. India. Indian Meteorological Memoirs. Vol. 4, part 4. Dallas. Memoir on the Winds and Monsoons of the Arabian Sea and North Indian Ocean. Calcutta, 1887. Report on the Meteorology of India. 1886. Presented by the Meteorological Department.

Meteorological Observations Recorded at Six Stations in India, December, 1887. Presented by the Meteorological Department.

Meteorological Office. London Monthly Weather Review. April, 1887. Weekly Weather Report, February 27th to May 7th, 1888, inclusive. Presented by the Office.

Michigan. Fourteenth Annual Report of the State Board of Health for 1886. Lansing, 1887. Baker, H. B. Causation of Pneumonia. Presented by the Board.

Milwaukee Annual Report of the Board of Public Works for 1887. Presented by the Board.

Morley, John. Life of Richard Cobden. London, 1882. Presented by Mr. L. S. Ware.

Morphy, Paul. Exploits and Triumphs. New York, 1859. Presented by Mr. S. H. Needles.

National Association of Builders. First and Second Conventions. Boston, 1887–1888. Presented by the Association.

National Association of Master Plumbers of the United States. Proceedings of First to Fifth Conventions. New York, etc. 1883 to 1887. Presented by the Association.

New Branswick, N. J. Fifteenth Annual Report of the Water Commissioners for 1887. Presented by the Commissioners.

New Haven. Annual Report of the Board of Health for 1887. Presented by the Board.

New Jersey Agricultural Experiment Station. Bulletins Nos. 44 and 45. Presented by Mr. L. S. Ware.

New Jersey Geological Survey. State Map. Presented by Prof. G. H. Cook, State Geologist.

New York City. Report of the Fire Department for 1880. New York, 1881. Presented by Mr. S. H. Needles.

Ordnance. Annual Report of the Chief for 1887. Washington, 1888.
Presented by the Chief of Ordnance.

Oregon. Resources of the State. Salem, 1888.
Presented by Mr. B. S. Payne.

Otto, Fr. Jul. Lehrbuch der Chemie. Braunschweig, 1848–49.
Presented by Mr. R. A. Fisher.

Painter's Manual. New York. Presented by Mr. S. H. Needles.

Patent Office, United States. Specifications and Drawings. January, 1887.
Presented by the Office.

Peabody Institute of Baltimore. Twenty-first Annual Report. 1888.
Presented by the Institute.

Pennsylvania Report of the Board of Commissioners of Public Charities for 1887. Presented by the Commissioners.

Pennsylvania State College Agricultural Experiment Station. Bulletin No. 3.
Presented by the Station.

Philadelphia Photographer. Vols. 1 to 3. 1864 to 1866.
Presented by Mr. W. B. Le Nau.

Philosophical Society of Washington. Bulletin. Vol. 10.
Presented by the Society.

Pratt Institute. Announcement, etc. 1888. Presented by the Institute.

Record Almanac. Philadelphia, 1881. Presented by Mr. S. H. Needles.

Roberts, Alex. Companion to the Revised Version of the New Testament.
Presented by Mr. L. S. Ware.

Ross, E. W. & Co. Ensilage and Silos. Presented by Mr. L. S. Ware.

Royal Society of New South Wales. Vol. 21. 1887.
Presented by the Society.

Salt Lake City. A Sketch of Utah's Wonderful Resources.
Presented by Mr. L. S. Ware.

Saward, F. E. Coal Trade. New York, 1878.
Presented by Mr. S. H. Needles.

Signal Office. Annual Report of the Chief Signal Officer for 1887. Part 1. Daily International Chart. April and May, 1887. Summary and Review of International Meteorological Observations for April and May, 1887.
Presented by the Office.

Signal Service, U. S. A. Contributions to the Natural History of Alaska, by L. M. Turner. Washington, 1886. Presented by the Signal Service.

Society of Engineers, London. Transactions for 1887.
Presented by the Society.

Somerville, Mass. Tenth Annual Report of the Board of Health for 1887.
Presented by the Board.

State School of Mines, Colorado. Annual Report for 1885–6–7.
Presented by the President.

Stevens Institute of Technology. Annual Catalogue for 1888–89.
Presented by the Institute.

Tatnall, E. Catalogue of the Phænogamous and Filicoid Plants of New Castle County, Del. Wilmington, 1860.
Presented by Wilmington Institute Library.

Teale, T. P. Dangers to Health. London, 1883.
Presented by Mr. Robt. W. Edison.

Texcoco—Huehuetoca Canal. Philadelphia, 1880.
Presented by Mr. L. S. Ware.

United States Geological Survey. Seventeen Atlas Sheets.
Presented by the Survey.

University of Wisconsin. Agricultural Experiment Station. Bulletins Nos. 14 to 16. 1888.
Presented by the Station.

Valin, R. J. Commentaire sur l'ordonnance de la Marine. Paris, 1841. Two vols.
Presented by Mr. S. H. Needles.

Verities in Verses. London, N.D. Presented by Mr. R. A. Macfie.

Waltham, Mass. Annual Report of the Board of Health for 1886 and 1887.
Presented by the Board.

Welsbach System of Incandescent Gas Lighting, Description, etc.
Presented by the Welsbach Company.

White, G. Political Economy. Easton, Mass., 1888.
Presented by the Author.

Women's Medical College of Pennsylvania. Thirty-ninth Annual Announcement.
Presented by the College.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, June 20, 1888.*]

HALL OF THE INSTITUTE, PHILADELPHIA, June 20, 1888.

Mr. JOS. M. WILSON, President, in the Chair.

Present, eighty-seven members and twenty-four visitors.

Additions to membership since previous report, six.

The Actuary reported the death of Mr. WILLIAM HELME, a member of the Board of Managers, and the appointment of a committee to prepare a memorial of the deceased.

Mr. WASHINGTON JONES announced the death of WM. PETTIT, one of the oldest members of the INSTITUTE, and moved the appointment of a committee to prepare a memorial, which was carried.

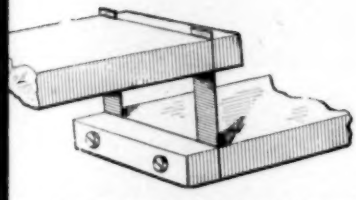
Mr. THEO. C. SEARCH was thereupon elected to fill the vacancy in the Board, *vice* Mr. HELME, deceased.

Mr. C. J. HEXAMER was elected to membership in the Committee on Science and the Arts, to fill the unexpired term of Mr. J. M. EMANUEL, resigned.

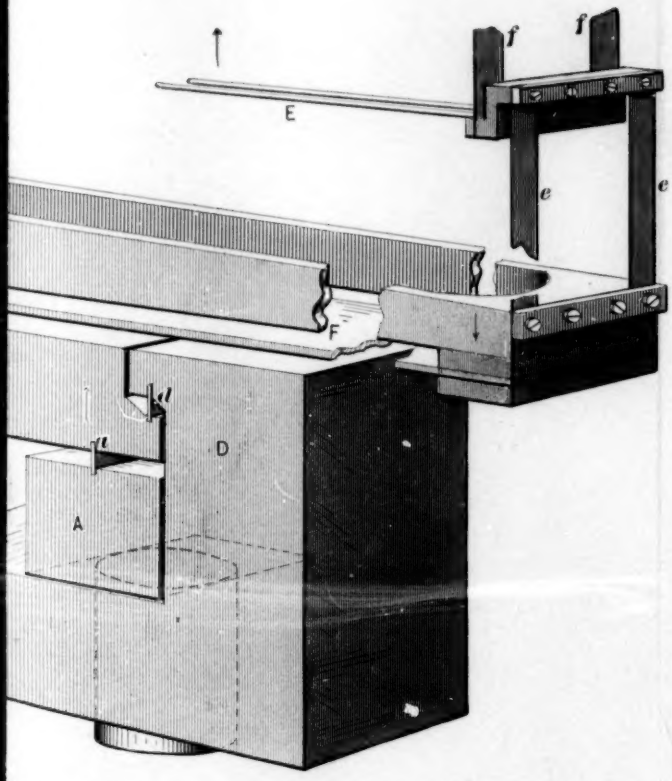
Mr. GEO. F. SIMONDS read a paper describing a Universal Metal Rolling Machine of his invention. The paper was illustrated by specimens of the work of the machine, and by a model machine rolling lead in various forms. The paper appears in the JOURNAL for July.

Adjourned.

WM. H. WAHL, *Secretary*.



15. Clamping Suspension Fulcrums.



G. 14. Levers and Plate Fulcrums.

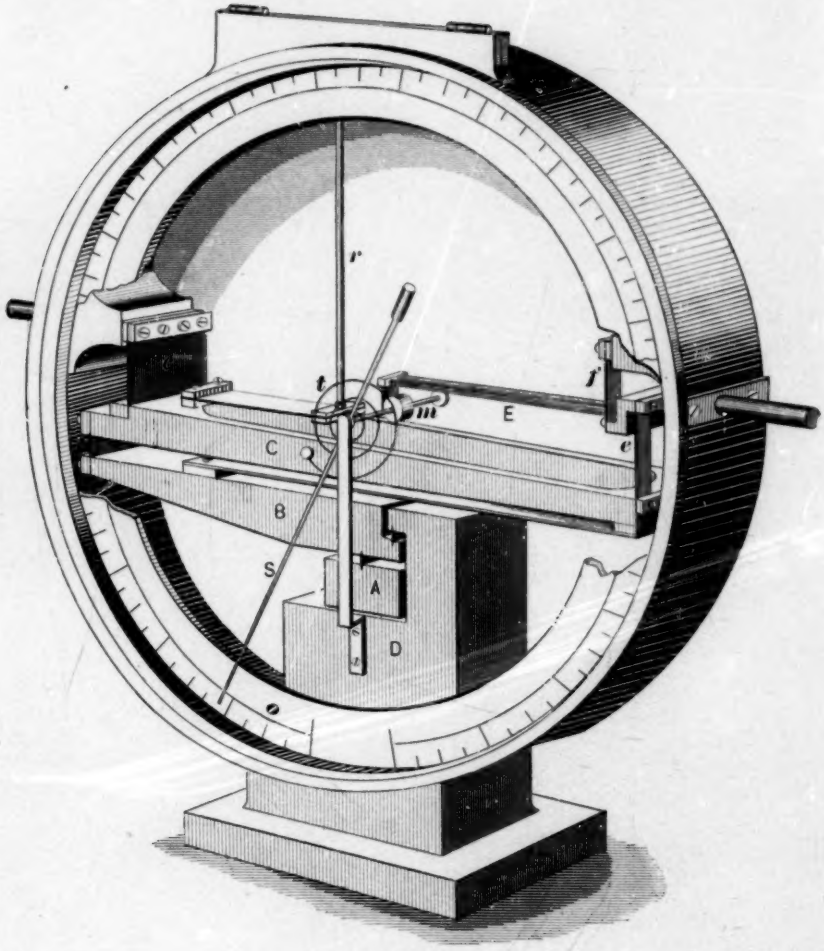


FIG. 16. Hydraulic Gauge.

a still greater antiquity, for among the earliest questions asked by man of his fellow-man must have been "How much does it weigh?" And the answer would have been given after reference to the first weighing machine, which is man's

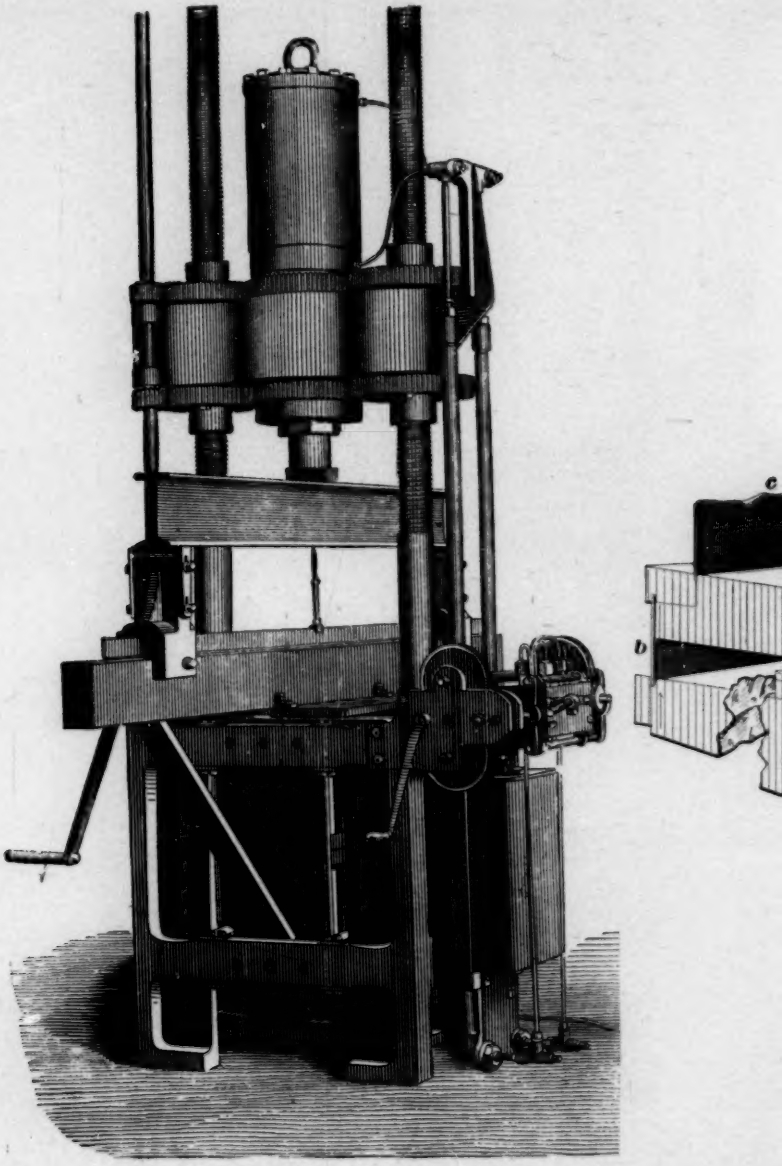


FIG. 13. Elevation of the Machine.

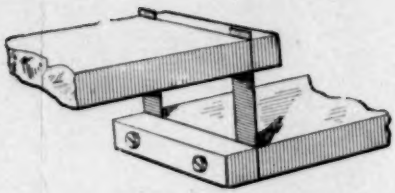


FIG. 15. Clamping Suspension Fulcrums.

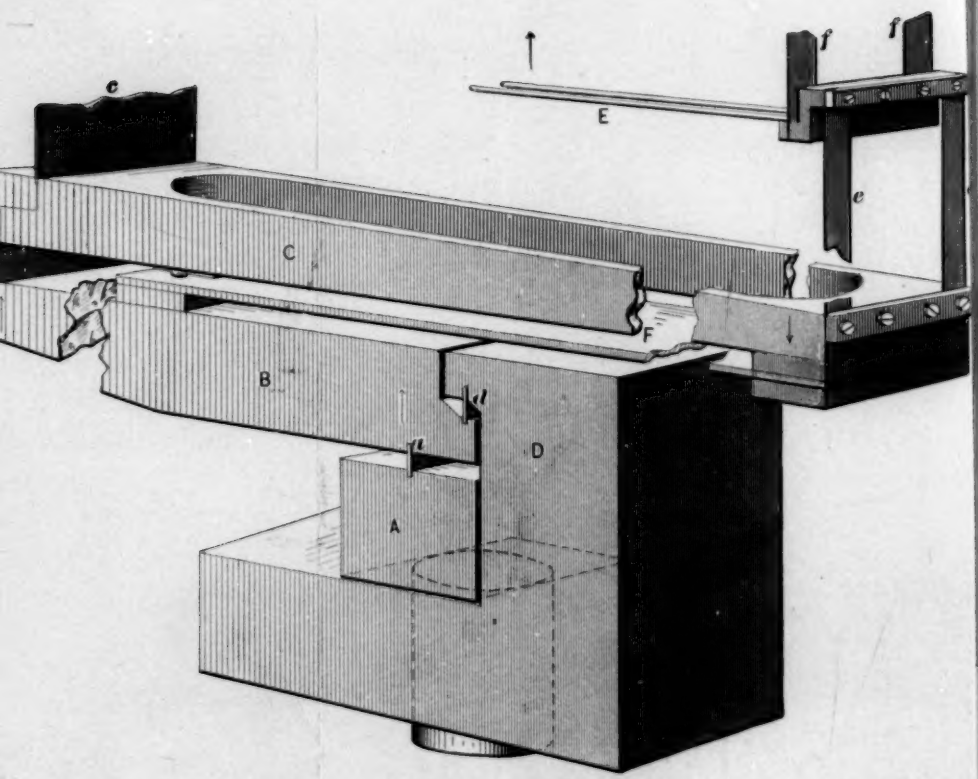


FIG. 14. Levers and Plate Fulcrums.